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PATENT ABSTRACTS OF JAPAN

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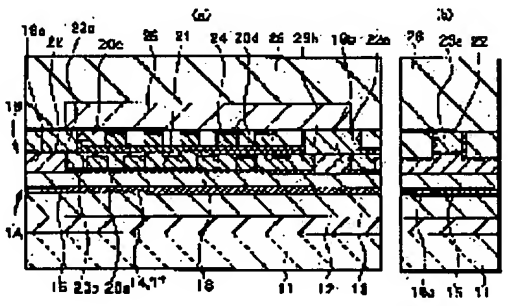
(54) THIN FILM MAGNETIC HEAD AND ITS PRODUCTION

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain a thin film magnetic head in which the throat height of a recording head can be accurately controlled.

SOLUTION: The lower magnetic pole of a recording head is bisected into a lower magnetic pole top end 19a and a lower magnetic pole layer 18. The lower magnetic pole top end 19a is formed in a projected shape on the flat face of the lower magnetic pole layer 18. A thin film coil 21 as a first layer together with insulating layers 20a, 20b made of an inorganic material are embedded in a recess formed between the lower magnetic pole top end 19a and a lower connecting part 19b. A throat height is stipulated by the edge of the insulating layer 20a on the lower magnetic pole top end 19a side, (namely, the edge opposite to the track face of the lower magnetic pole top end 19a). Therefore, unlike a conventional photoresist film, no changes in the position of the edge (pattern shift) nor the degradation of a profile are caused but the throat height can be accurately controlled. Further, the length of the upper magnetic pole top end 23a from the track face is larger than the length of the lower magnetic pole top end 19a and a contact area between the upper magnetic pole top end 23a and the upper magnetic layer 25 becomes wide as much as the length.



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CLAIMS

[Claim(s)]
[Claim 1] At least two magnetic layers containing the 1st magnetic pole and 2nd magnetic pole which the part of the side which is connected magnetically and counters a record medium counters through a record gap layer, While being the thin film magnetic head which has a thin film coil more than two-layer [for generating magnetic flux / one layer or two-layer], dividing with the 1st magnetic layer and this 1st magnetic layer and being formed While the field of the opposite side of a contact surface with said record gap side is formed in the 1st magnetic pole magnetically combined with the field in part and the inorganic system ingredient of said 1st magnetic layer While countering said 1st magnetic pole through the insulating layer continuously formed in one field of said 1st magnetic layer, and said record gap layer from the opposite side of the side which counters said record medium of said 1st magnetic pole at least While dividing with the 2nd magnetic pole formed towards the back side for a long time than said 1st magnetic pole from the field which counters said record medium, and this 2nd magnetic pole and being formed The thin film magnetic head characterized by having the 2nd magnetic layer magnetically combined with said 2nd magnetic pole in a part of field [at least] of the opposite side of a contact surface with said record gap side of said 2nd magnetic pole.
[Claim 2] The thin film magnetic head according to claim 1 to which die length from the field which counters said record medium of said 1st magnetic pole is characterized by being equal to the throat height of a recording head.
[Claim 3] Said 2nd magnetic pole is the thin film magnetic head according to claim 1 or 2 to which only an equivalent for the thickness of said 2nd magnetic pole is characterized by the ******** rather than said 1st magnetic pole.
[Claim 4] The thin film magnetic head given in claim 1 to which much more thin film coil is characterized by being formed so that a part of the direction of thickness may be located at least in the field in which said insulating layer is formed at least thru/or any 1 term of 3.
[Claim 5] Said insulating layer is the thin film magnetic head according to claim 4 characterized by including the 1st insulating layer continuously formed along one field of said 1st magnetic layer from the opposite side of the side which counters said record medium of said 1st magnetic pole, and the 2nd insulating layer formed between the coils of said thin film coil at least.
[Claim 6] The thin film magnetic head given in claim 1 characterized by being formed so that the opposite side of a contact surface with said 1st magnetic layer of said insulating layer may turn into substantially an opposite side of a contact surface with said record gap layer of said 1st magnetic pole with the same side thru/or any 1 term of 3.
[Claim 7] The thin film magnetic head according to claim 6 characterized by forming more widely than the width of face of said 2nd magnetic pole the width of face along the field which counters said record medium of said 1st magnetic pole.
[Claim 8] Furthermore, it sets near the edge of the opposite side the side which counters said record medium of said 2nd magnetic layer. It has the 1st connection which adjoined said 1st magnetic layer and was formed, and the 2nd connection which adjoined said 2nd magnetic layer and was formed in the

location which counters this 1st connection. And the thin film magnetic head given in claim 1 characterized by the area of the side which counters mutually [said 1st connection and said each of 2nd connection] differing thru/or any 1 term of 7.
[Claim 9] The thin film magnetic head according to claim 8 characterized by the area of said 2nd connection being larger than that of said 1st connection.
[Claim 10] The edge by the side of the field which counters said record medium of said 2nd magnetic layer is the thin film magnetic head given in claim 1 characterized by being formed in the location which retreated from the field which counters said record medium thru/or any 1 term of 9.
[Claim 11] Said 1st insulating layer is the thin film magnetic head given in claim 5 characterized by being further formed along the both-sides side except the end face of the side which counters said record medium of said 1st magnetic pole thru/or any 1 term of 9.
[Claim 12] The thin film magnetic head given in claim 5 characterized by forming all of the directions of thickness of said thin film coil in the field in which said 1st insulating layer is formed thru/or any 1 term of 10.
[Claim 13] The thin film magnetic head according to claim 12 characterized by being formed so that said 2nd insulating layer may serve as substantially a contact surface with said record gap layer of said 1st magnetic pole with the same side.
[Claim 14] The thin film magnetic head according to claim 13 characterized by being formed so that one field of said record gap layer may cover said 2nd insulating layer.
[Claim 15] Furthermore, the thin film magnetic head according to claim 14 characterized by the 3rd insulating layer being missing from the field of another side of said record gap layer, and forming it continuously at least from the opposite side of the side which counters said record medium of said 2nd magnetic pole.
[Claim 16] The thin film magnetic head according to claim 15 characterized by having the thin film coil of at least one layer which was covered with other different insulating layers from said the 1st thru/or 3rd insulating layer, and was further formed between said 3rd insulating layer and said 2nd magnetic layer at them.
[Claim 17] The thin film magnetic head according to claim 16 characterized by being formed so that said the 3rd insulating layer and other insulating layers may serve as substantially an opposite side of a contact surface with said record gap layer of said 2nd magnetic pole with the same side.
[Claim 18] Furthermore, the thin film magnetic head given in claim 1 characterized by having a magneto-resistive effect component for read-out thru/or any 1 term of 17.
[Claim 19] At least two magnetic layers containing the 1st magnetic pole and 2nd magnetic pole which the part of the side which is connected magnetically and counters a record medium counters through a record gap layer, It is the manufacture approach of the thin film magnetic head of having a thin film coil more than two-layer [for generating magnetic flux / one layer or two-layer]. After forming the 1st magnetic layer, said 1st magnetic layer a part on said 1st magnetic layer The process which forms the 1st magnetic pole so that it may be magnetically combined with a field, The process which forms continuously the insulating layer which is missing from one field of said 1st magnetic layer from the opposite side of the side which counters said record medium of said 1st magnetic pole at least, and consists of an inorganic system ingredient, The process which forms said 2nd magnetic pole towards a back side for a long time than said 1st magnetic pole from the field which counters said record medium after forming a record gap layer on said 1st magnetic pole at least, The manufacture approach of the thin film magnetic head characterized by including the process which is magnetically combined with said 2nd magnetic pole, and forms the 2nd magnetic layer.
[Claim 20] Furthermore, while adjoining said 1st magnetic layer and forming the 1st connection in the location near the edge of the side which counters said record medium of said 2nd magnetic layer, and the opposite side at the same time it forms said 1st magnetic pole In the location near the edge of the side which counters said record medium of said 2nd magnetic layer at the same time it forms said 2nd magnetic pole, and the opposite side The manufacture approach of the thin film magnetic head according to claim 19 characterized by adjoining said 2nd magnetic layer and forming the 2nd

connection of a different area from said 1st connection.
[Claim 21] The manufacture approach of the thin film magnetic head according to claim 19 or 20 characterized by including the process which forms much more thin film coil at least so that a part of the direction of thickness may be located at least in the field in which said insulating layer is formed.
[Claim 22] The manufacture approach of the thin film magnetic head according to claim 21 characterized by including the process which forms the 1st insulating layer continuously along one field of said 1st magnetic layer from the opposite side of the side which counters said record medium of said 1st magnetic pole, and the process which forms the 2nd insulating layer between the coils of said thin film coil at least.
[Claim 23] The manufacture approach of the thin film magnetic head according to claim 22 characterized by including the process which carries out flattening so that the opposite side of a contact surface with said 1st magnetic layer of said 2nd insulating layer may turn into substantially an opposite side of a contact surface with said record gap layer of said 1st magnetic pole with the same side.
[Claim 24] The manufacture approach of the thin film magnetic head given in claim 19 characterized by forming more widely than said 2nd magnetic pole the width of face along the field which counters said record medium of said 1st magnetic pole thru/or any 1 term of 23.
[Claim 25] The manufacture approach of the thin film magnetic head given in claim 19 characterized by forming all of the directions of thickness of said thin film coil in the field in which said 1st insulating layer is formed thru/or any 1 term of 24.
[Claim 26] After carrying out flattening of said 2nd insulating layer, a record gap layer is formed on said 2nd insulating layer. After forming said 2nd magnetic pole on said record gap layer, the 3rd insulating layer is formed on said record gap layer at least. Then, the manufacture approach of the thin film magnetic head according to claim 25 which forms the thin film coil of at least one layer on said 3rd insulating layer on said record gap layer, and is characterized by covering said thin film coil continuously by other different insulating layers from said the 1st thru/or 3rd insulating layer.
[Claim 27] said -- others -- after forming an insulating layer with an inorganic system ingredient -- said -- others -- the manufacture approach of the thin film magnetic head according to claim 26 which carries out flattening of the insulating layer so that the front face may form the same field as the front face of said 2nd magnetic pole, and is characterized by forming said 2nd magnetic layer after that on said 2nd magnetic pole and other insulating layers by which flattening was carried out.
[Claim 28] The manufacture approach of the thin film magnetic head according to claim 27 characterized by forming said 2nd magnetic layer on said 2nd magnetic pole and other insulating layers after forming an insulating layer besides the above alternatively with an organic system ingredient.
[Claim 29] Furthermore, the manufacture approach of the thin film magnetic head given in claim 19 characterized by including the process which forms the magneto-resistive effect component for read-out thru/or any 1 term of 28.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the manufacture approach of the thin film magnetic head which writes in at least and has the induction type MAG sensing element of business, and the thin film magnetic head.
[0002]
[Description of the Prior Art] In recent years, the improvement in the engine performance of the thin film magnetic head is called for with improvement in the surface recording density of a hard disk drive unit. The compound-die thin film magnetic head of the structure which carried out the laminating of the reproducing head which reads as the thin film magnetic head with the recording head which has an induction type MAG sensing element for writing, and has the magnetic-reluctance (it is hereafter described as MR (Magneto Resistive).) component of business is used widely. As a MR component, there are an AMR component using the film which has the anisotropy magnetic-reluctance (it is hereafter described as AMR (Anisotropic Magneto Resistive).) effectiveness, and a GMR component using the film which has the huge magnetic-reluctance (it is hereafter described as GMR (Giant Magneto Resistive).) effectiveness, it is only called an MR head and the AMR head or the reproducing head using a GMR component is called a GMR head for the reproducing head using the AMR component. For the AMR head, surface recording density is 1 gigabit / (inch) 2. It is used as the reproducing head which exceeds and, for a GMR head, surface recording density is 3 gigabit / (inch) 2. It is used as the reproducing head which exceeds.
[0003] Generally, the AMR film is what used as the film the magnetic substance in which the MR effectiveness is shown, and has monolayer structure. On the other hand, many GMR film has multilayer structure which combined two or more film. There are some classes of the mechanisms which the GMR effectiveness generates, and the layer structure of the GMR film changes according to the mechanism. As GMR film, although the superlattice GMR film, the spin bulb film, a granular membrane, etc. are proposed, a configuration is comparatively simple, a weak field also shows a big resistance change and the spin bulb film is leading as GMR film on condition of mass production.
[0004] As a factor which opts for the engine performance of the reproducing head, there are pattern width of face, especially MR height. MR height says the die length (height) from the edge by the side of the air bearing side of MR component to the edge of the opposite side. Originally this MR height is controlled by the amount of polishes in the case of processing of an air bearing side. In addition, the air bearing side (ABS) said here is a field which counters the magnetic-recording medium of the thin film magnetic head, and is also called truck side.
[0005] On the other hand, the improvement in the engine performance of a recording head is also called for with the improvement in the engine performance of the reproducing head. In order to raise recording density among the engine performance of a recording head, it is necessary to raise the track density in a magnetic-recording medium. For that purpose, it is necessary to realize the recording head of the ** truck structure which narrowed width of face in the air bearing side of the lower magnetic pole (bottom

pole) formed up and down and an up magnetic pole (top pole) from several microns to submicron order on both sides of the record gap (write gap), therefore the semi-conductor processing technique is used.
[0006] As a factor of others which opt for the engine performance of a recording head, it is throat height (ThroatHeight:TH). It is. Throat height says the die length (height) of the part (magnetic pole part) from an EABE ring side to the edge of the insulating layer which separates a thin film coil electrically. Contraction-ization of throat height is desired for the improvement in the engine performance of a recording head. This throat height is also controlled by the amount of polishes in the case of processing of an air bearing side.
[0007] For improvement in the engine performance of the thin film magnetic head, it is important to form the above recording heads and reproducing heads with sufficient balance.
[0008] Here, with reference to drawing 11 (a), (b), or drawing 24 (a) and (b), an example of the manufacture approach of the compound-die thin film magnetic head is explained as an example of the conventional thin film magnetic head.
[0009] First, as shown in drawing 11 , the insulating layer 102 which consists of an alumina (an aluminum oxide and aluminum 2O3) is formed by the thickness of about about 5-10 micrometers on the substrate 101 which consists of ARUTIKKU (aluminum 2O3 and TiC). Then, the lower shielding layer 103 for the reproducing heads which consists of a permalloy (NiFe) is formed on an insulating layer 102.
[0010] Next, as shown in drawing 12 , on the lower shielding layer 103, an alumina is deposited by the thickness of 100-200nm, and the shielding gap film 104 is formed. Next, the MR film 105 for constituting MR component for playback is formed on the shielding gap film 104 at the thickness of dozens of nm, and it considers as a desired configuration by the highly precise photolithography. Then, the lead terminal layer 106 to this MR film 105 is formed by the lift-off method. Subsequently, the shielding gap film 107 is formed on the shielding gap film 104, the MR film 105, and the lead terminal layer 106, and the MR film 105 and the lead terminal layer 106 are laid underground in the shielding gap film 104,107. Then, the lower [up shielding-cum-] magnetic pole (it is hereafter described as a lower magnetic pole.) 108 of 3 micrometers of thickness which consists of a magnetic adjuster used for the both sides of the reproducing head and a recording head, for example, a permalloy, (NiFe) is formed on the shielding gap film 107.
[0011] Next, as shown in drawing 13 , the record gap layer 109 of 200nm of thickness which consists of an insulating layer, for example, the alumina film, is formed on the lower magnetic pole 108. Furthermore, patterning of this record gap layer 109 is carried out by the photolithography, and opening 109a for connection between an up magnetic pole and a lower magnetic pole is formed. Then, while forming the magnetic pole point (pole chip) 110 with the magnetic adjuster which consists of a permalloy (NiFe) or nitriding iron (FeN) by the galvanizing method, connection pattern 110a of an up magnetic pole and a lower magnetic pole is formed. The lower magnetic pole 108 and the below-mentioned up magnetic pole layer 116 are connected by this connection pattern 110a, and formation of opening (through hole) after the below-mentioned CMP (Chemical and Mechanical Polishing: chemical mechanical polishing) process becomes easy.
[0012] Next, as shown in drawing 14 , the record gap layer 109 and about about 0.3-0.5 micrometers of lower magnetic poles 108 are etched by ion milling by using the magnetic pole point 110 as a mask. Effective write-in truck broadening is prevented by etching to the lower magnetic pole 108 and considering as trim structure (that is, in the time of the writing of data, the breadth of the magnetic flux in a lower magnetic pole is controlled). Then, after forming in the whole surface the insulating layer 111 of about 3 micrometers of thickness which consists of an alumina, flattening of the whole surface is carried out by CMP.
[0013] Next, as shown in drawing 15 , on an insulating layer 111, for example, by the galvanizing method, the thin film coil 112 of the 1st layer for the recording heads of the induction type which consists of copper (Cu) is formed alternatively, and the photoresist film 113 is further formed on an insulating layer 111 and the thin film coil 112 at a pattern predetermined by the highly precise photolithography. Then, it heat-treats at predetermined temperature for flattening of the photoresist film

113, and insulation-izing between the thin film coils 112. Furthermore, similarly, the thin film coil 114 and the photoresist film 115 of the 2nd layer are formed on the photoresist film 113, and it heat-treats at predetermined temperature for flattening of the photoresist film 115, and insulation-izing between the thin film coils 114.

[0014] Next, as shown in drawing 16 , the up [up York-cum-] magnetic pole layer (it is hereafter described as an up magnetic pole layer.) 116 which consists of a magnetic adjuster for recording heads, for example, a permalloy, is formed on the magnetic pole point 110 and the photoresist film 113,115. Besides, rather than the thin film coil 112,114, in a back location, the section magnetic pole layer 116 contacts the lower magnetic pole 108, and is connected magnetically. Then, the overcoat layer 117 which consists of an alumina is formed on the up magnetic pole layer 116. Finally, a slider is machined, the truck side (air bearing side) 118 of a recording head and the reproducing head is formed, and the thin film magnetic head is completed.

[0015] In drawing 16 , TH expresses throat height and MR-H expresses MR height, respectively. Moreover, P2W express truck (magnetic pole) width of face.

[0016] There is an apex angle type (Apex Angle) as shown by theta else [, such as the throat height TH and MR height MR-H,] in drawing 16 as a factor which opts for the engine performance of the thin film magnetic head. This apex angle type says the include angle of the straight line which connects the corner of the side face by the side of the truck side of the photoresist film 113,115, and the top face of the up magnetic pole layer 116 to make.

[0017]

[Problem(s) to be Solved by the Invention] In order to raise the engine performance of the thin film magnetic head, it is important to form correctly the throat height TH as shown in drawing 16 , MR height MR-H, the apex angle type theta, and width-of-recording-track P2W.

[0018] In order to enable high surface density record especially in recent years (i.e., in order to form the recording head of ** truck structure), the submicron dimension of 1.0 micrometers or less is demanded of width-of-recording-track P2W. Therefore, the technique of processing an up magnetic pole into submicron one using a semi-conductor processing technique is needed. Moreover, it follows on becoming ** truck structure, and the magnetic pole is expected use of a magnetic material with higher saturation magnetic flux density.

[0019] Here, it poses a problem that it is difficult to form minutely the up magnetic pole layer (top pole) 116 formed on the coil part (apex section) which was covered by the photoresist film (for example, photoresist film 113,115 of drawing 16), and rose in the shape of a crest.

[0020] As an approach of forming an up magnetic pole, as shown, for example in JP,7-262519,A, the frame galvanizing method is used. When forming an up magnetic pole using the frame galvanizing method, on the whole, the thin electrode layer which consists of a permalloy is first formed on the apex section. Next, on it, a photoresist is applied, patterning is carried out by the photolithography, and the frame for plating (outer frame) is formed. And an up magnetic pole is formed by the galvanizing method by using as a seed layer the electrode layer formed previously.

[0021] By the way, in the above-mentioned apex section, there is the difference of elevation 7-10 micrometers or more, for example. Supposing at least 3 micrometers or more of thickness of the photoresist formed on this apex section are required, since the photoresists with a fluidity gather in the lower one, in the lower part of the apex section, the photoresist film with a thickness of 8-10 micrometers or more will be formed, for example. In order to form a ** truck as mentioned above, it is necessary to form the pattern of submicron width of face with the photoresist film. Therefore, this was very difficult although it will be necessary to form a pattern with detailed submicron width of face with the photoresist film with the thickness of 8-10 micrometers or more.

[0022] And at the time of exposure of a photolithography, the light for exposure reflects by the electrode layer which consists of a permalloy, also by this reflected light, a photoresist exposes and collapse of a photoresist pattern etc. arises. It becomes impossible consequently, to form that the side attachment wall of an up magnetic pole becomes roundish [wore] etc. in the configuration of a request of an up magnetic pole. Thus, it was very difficult to form the up magnetic pole for controlling truck P2W

correctly and considering as ** truck structure conventionally, with a sufficient precision.
[0023] From such a thing, as the process of drawing 13 of the above-mentioned conventional example - drawing 16 also showed After forming the width of recording track of 1.0 micrometers or less by the magnetic pole point 110 effective in formation of the ** truck of a recording head, The magnetic pole point 110 which determines the width of recording track for the approach of connecting the up magnetic pole layer 116 which serves both as this magnetic pole point 110 and the York section, i.e., the usual up magnetic pole, The approach of dividing into two with the up magnetic pole layers 116 used as the York section for guiding magnetic flux is adopted (refer to JP,62-245509,A and JP,60-10409,A). Thus, by dividing an up magnetic pole into two, it becomes possible to process one magnetic pole point 110 into submicron width of face minutely on the flat side of the record gap layer 109.
[0024] However, in this thin film magnetic head, there were still the following problems.
[0025] (1) By the conventional magnetic head, throat height is first determined in the edge of a side far from the truck side 118 of the magnetic pole point 110. However, if the width of face of this magnetic pole point 110 becomes narrow, in photolithography, a pattern edge will be roundish and will be formed. Therefore, the throat height of which a highly precise dimension is required became uneven, and the situation where the balance between the width of recording track of a magneto-resistive effect component was missing had occurred in processing of a truck side, and a polish process. For example, as the width of recording track, the edge of a side far from the truck side 118 of the magnetic pole point 110 by the way which is 0.5-0.6-micrometer need shifted from the location of throat height zero to the truck side side, the write-in gap opened greatly, and the problem of the writing of record data becoming impossible often occurred.
[0026] (2) Next, as mentioned above, by the conventional magnetic head, since the width of recording track of a recording head is prescribed by one magnetic pole point 110 of the up magnetic poles divided into two, it can be said that it is not necessary to process minutely the up magnetic pole layer 116 of another side into about 110 magnetic pole point. However, if both sides do the location gap of the up magnetic pole layer 116 greatly in one side when it sees from the truck side 118 (drawing 16) side since a location is determined as the upper part of the magnetic pole point 110 by the alignment of photolithography, the so-called side light which writes in by the up magnetic pole layer 116 side will generate it. Therefore, the effective width of recording track becomes large, and the fault that writing is performed also in fields other than an original data storage area occurs in a hard disk.
[0027] Moreover, if the width of recording track of a recording head is set to microscopic **, especially 0.5 micrometers or less, also in the up magnetic pole layer 116, the process tolerance of submicron width of face will be required. That is, if the variation of tolerance of the longitudinal direction of the magnetic pole point 110 and the up magnetic pole layer 116 is too large when it sees from the truck side 118 (drawing 16) side, like the above, a side light will be generated and the fault that writing is performed also in fields other than an original data storage area will occur.
[0028] Since it was such, not only the magnetic pole point 110 but the up magnetic pole layer 116 needed to be processed into submicron width of face, but since there were still the above big differences of elevation in the apex section under the up magnetic pole layer 116, micro processing of the up magnetic pole layer 116 was difficult for it.
[0029] (3) In the further conventional magnetic head, there was a problem that it was difficult to shorten magnetic-path length (Yoke Length). That is, the recording head which could realize the short head of magnetic-path length and was excellent in especially the high frequency property could be formed so that the coil pitch was narrow, but when a coil pitch was made small infinite, the distance of the periphery edge of a coil had become the big factor which bars magnetic-path length from the location of throat height zero. Since magnetic-path length can do the two-layer coil short rather than much more coil, the recording head for many RFs has adopted the two-layer coil. However, by the conventional magnetic head, after forming the coil of the 1st layer, in order to form the insulator layer between coils, the photoresist film is formed by the thickness of about 2 micrometers. Therefore, the small apex roundish [wore] is formed in the periphery edge of the coil of the 1st layer. Next, although the coil of a two-layer eye is formed on it, since etching of the seed layer of a coil cannot be performed but a coil

short-circuits by the ramp of the apex section in that case, the coil of a two-layer eye cannot be formed. Therefore, it is necessary to form the coil of a two-layer eye in a flat part. If the thickness of a coil is 2-3 micrometers and sets thickness of the insulator layer between coils to 2 micrometers further When the inclination of an apex is 45 - 55 degrees, twice [with a distance of 4-5 micrometers] (the distance from the contact section of an up magnetic pole and a lower magnetic pole to a coil periphery edge is also 4-5-micrometer need) as many 8-10 micrometers as this are [to / from the periphery edge of a coil / near the location of the zero of throat height] required. This had become the factor which bars contraction of magnetic-path length. For example, when Rhine/tooth space forms the 11-volume coil which are 1.0 micrometers / 1.0 micrometers by two-layer, the 1st layer is made into six volumes and a two-layer eye is made into five volumes, the die length of the part which occupies the coil of magnetic-path length is 11 micrometers. Here, since 8-10 micrometers was the need, more than this, contraction of magnetic-path length was impossible in the apex section of the above-mentioned coil periphery edge, and this had barred the improvement of a RF property in it.

[0030] This invention was made in view of this trouble, and the 1st purpose is in offering the thin film magnetic head in which exact control is possible and its manufacture approach of the throat height in a recording head.

[0031] Moreover, in addition to exact control of throat height, pole micro processing of the submicron width of face of not only a magnetic pole point but an up magnetic pole layer is possible for the 2nd purpose of this invention, and it is to offer the thin film magnetic head by which the property of a recording head has been improved, and its manufacture approach.

[0032] Furthermore, in addition to exact control of throat height, the contraction of magnetic-path length in a recording head is possible for the 3rd purpose of this invention, and it is to offer the thin film magnetic head by which the RF property has been improved, and its manufacture approach.

[0033]

[Means for Solving the Problem] At least two magnetic layers containing the 1st magnetic pole and 2nd magnetic pole which the part of the side which the thin film magnetic head by this invention is connected magnetically, and counters a record medium counters through a record gap layer, While being the thin film magnetic head which has a thin film coil more than two-layer [for generating magnetic flux / one layer or two-layer], dividing with the 1st magnetic layer and this 1st magnetic layer and being formed While the field of the opposite side of a contact surface with a record gap side is formed in the 1st magnetic pole magnetically combined with the field in part and the inorganic system ingredient of the 1st magnetic layer While countering the 1st magnetic pole through the insulating layer continuously formed in one field of the 1st magnetic layer, and a record gap layer from the opposite side of the side which counters the record medium of the 1st magnetic pole at least While dividing with the 2nd magnetic pole formed towards the back side for a long time than the 1st magnetic pole from the field which counters a record medium, and this 2nd magnetic pole and being formed It has the configuration equipped with the 2nd magnetic layer magnetically combined with the 2nd magnetic pole in a part of field [at least] of the opposite side of a contact surface with the record gap side of the 2nd magnetic pole.

[0034] In the thin film magnetic head by this invention, since the 1st magnetic pole is divided with the 1st magnetic layer and formed in the shape of ** to the 1st magnetic layer, the insulating layer formed with the inorganic system ingredient adjoins the 1st magnetic pole, and is formed. Therefore, throat height is correctly prescribed by by making equal to the throat height of a recording head the die length to the depth direction from the field which counters the record medium of the 1st magnetic pole. Moreover, since it was made to make longer than the 1st magnetic pole the die length of the 2nd magnetic pole which counters the 1st magnetic pole through a record gap layer, the touch area of the 2nd magnetic pole and the 2nd magnetic layer can be secured enough, and magnetic association with the 2nd magnetic pole and the 2nd magnetic layer becomes good.

[0035] Furthermore, the level difference of the apex section containing the part and a coil becomes low compared with structure conventionally by embedding a thin film coil in the field in which the insulating layer is formed. Therefore, in case the 2nd magnetic pole is formed with a photolithography

technique, the difference of the thickness of the photoresist film is reduced in the upper part and the lower part of the apex section. Therefore, detailed-ization of the submicron dimension of the 2nd magnetic pole is attained.

[0036] In addition to the above-mentioned configuration, in the thin film magnetic head by this invention, it can consider as the mode of further the following.

[0037] That is, as for the die length from the field which counters the record medium of the 1st magnetic pole in the thin film magnetic head by this invention, it is desirable to make it equal to the die length of the throat height of a recording head.

[0038] Moreover, as for the 2nd magnetic pole, in the thin film magnetic head by this invention, it is more desirable than the 1st magnetic pole to lengthen only an equivalent for the thickness of the 2nd magnetic pole.

[0039] In the thin film magnetic head by this invention, moreover, much more thin film coil at least Are good also as a configuration formed so that a part of the direction of thickness may be located at least in the field in which said insulating layer is formed. Or an insulating layer may constitute so that the 1st insulating layer continuously formed along one field of the 1st magnetic layer from the opposite side of the side which counters the record medium of the 1st magnetic pole, and the 2nd insulating layer formed between the coils of a thin film coil at least may be included. Furthermore, you may make it form so that the opposite side of a contact surface with the 1st magnetic layer of an insulating layer may turn into substantially an opposite side of a contact surface with the record gap layer of the 1st magnetic pole with the same side.

[0040] Moreover, it is good also as a configuration in which the width of face which met the field which counters the record medium of the 1st magnetic pole in the thin film magnetic head by this invention is formed more widely than the width of face of the 2nd magnetic pole.

[0041] Furthermore, in the thin film magnetic head by this invention, it sets near the edge of the opposite side the side which counters the record medium of the 2nd magnetic layer. It has the 1st connection which adjoined the 1st magnetic layer and was formed, and the 2nd connection which adjoined the 2nd magnetic layer and was formed in the location which counters this 1st connection. And it is good also as a configuration from which the area of the side which counters mutually [the 1st connection and each 2nd connection] differs, and good also as a configuration with an area of the 2nd connection still larger than that of the 1st connection.

[0042] Moreover, it is desirable that the edge by the side of the field which counters the record medium of the 2nd magnetic layer considers as the configuration currently formed in the location which retreated from the field which counters a record medium in the thin film magnetic head by this invention.

[0043] Furthermore, in the thin film magnetic head by this invention, it is good also as a configuration currently formed in the field in which the 1st insulating layer is formed for all of the directions of thickness of a thin film coil by the 1st insulating layer considering as the configuration currently formed along the both-sides side except the end face of the side which counters the record medium of the 1st magnetic pole. It is good also as a configuration currently formed so that the 2nd insulating layer may furthermore serve as substantially a contact surface with the record gap layer of the 1st magnetic pole with the same side.

[0044] Moreover, in the thin film magnetic head by this invention, it is formed so that one field of a record gap layer may cover the 2nd insulating layer, and the 3rd insulating layer is still better at least also as a configuration in which it applies to the field of another side of a record gap layer from the opposite side of the side which counters the record medium of the 2nd magnetic pole, and is formed continuously. Furthermore, it is good also as a configuration equipped with the thin film coil of at least one layer which was covered with other different insulating layers from the 1st thru/or the 3rd insulating layer, and was formed between the 3rd insulating layer and the 2nd magnetic layer at them. Moreover, it is good also as a configuration currently formed so that the 3rd insulating layer and other insulating layers may serve as substantially an opposite side of a contact surface with the record gap layer of the 2nd magnetic pole with the same side.

[0045] Furthermore, it is good also as a configuration equipped with the magneto-resistive effect

component for read-out in the thin film magnetic head by this invention.
[0046] At least two magnetic layers containing the 1st magnetic pole and 2nd magnetic pole which the part of the side which the manufacture approach of the thin film magnetic head by this invention is connected magnetically, and counters a record medium counters through a record gap layer, It is the manufacture approach of the thin film magnetic head of having a thin film coil more than two-layer [for generating magnetic flux / one layer or two-layer]. After forming the 1st magnetic layer, the 1st magnetic layer a part on the 1st magnetic layer The process which forms the 1st magnetic pole so that it may be magnetically combined with a field, The process which forms continuously the insulating layer which is missing from one field of the 1st magnetic layer from the opposite side of the side which counters the record medium of the 1st magnetic pole at least, and consists of an inorganic system ingredient, After forming a record gap layer on said 1st magnetic pole at least, the process which forms said 2nd magnetic pole towards a back side for a long time than said 1st magnetic pole from the field which counters a record medium, and the process which is magnetically combined with the 2nd magnetic pole and forms the 2nd magnetic layer are included.
[0047] By the manufacture approach of the thin film magnetic head by this invention, the insulating layer in which the 1st magnetic pole was formed in in the shape of ** to the 1st magnetic layer, and was formed with the inorganic system ingredient adjoins the 1st magnetic pole, and is formed. Therefore, throat height is correctly prescribed by by making equal to the die length of the throat height of a recording head the die length to the depth direction from the field which counters the record medium of the 1st magnetic pole. Moreover, since the die length of the 2nd magnetic pole which counters the 1st magnetic pole through a record gap layer is formed for a long time than the 1st magnetic pole, the touch area of the 2nd magnetic pole and the 2nd magnetic layer is secured, and magnetic association with the 2nd magnetic pole and the 2nd magnetic layer becomes good.
[0048] In addition to the above-mentioned configuration, by the manufacture approach of the thin film magnetic head by this invention, it can consider as the mode of further the following.
[0049] namely, by the manufacture approach of the thin film magnetic head by this invention While adjoining the 1st magnetic layer and forming the 1st connection in the location near the edge of the side which counters the record medium of the 2nd magnetic layer, and the opposite side at the same time it forms the 1st magnetic pole The 2nd magnetic layer is adjoined and you may make it form the 2nd connection of a different area from the 1st connection in the location near the edge of the side which counters the record medium of the 2nd magnetic layer, and the opposite side at the same time it forms the 2nd magnetic pole.
[0050] moreover, by the manufacture approach of the thin film magnetic head by this invention You may make it include the process which forms much more thin film coil at least so that a part of the direction of thickness may be located at least in the field in which the insulating layer is formed. Or the process which forms the 1st insulating layer continuously along one field of the 1st magnetic layer from the opposite side of the side which counters the record medium of the 1st magnetic pole, You may make it include the process which forms the 2nd insulating layer between the coils of a thin film coil at least. Furthermore, you may make it include the process which carries out flattening so that the opposite side of a contact surface with the 1st magnetic layer of the 2nd insulating layer may turn into substantially an opposite side of a contact surface with said record gap layer of the 1st magnetic pole with the same side.
[0051] Furthermore, you may make it form more widely than the 2nd magnetic pole the width of face along the field which counters the record medium of the 1st magnetic pole by the manufacture approach of the thin film magnetic head by this invention.
[0052] Moreover, you may make it form all of the directions of thickness of a thin film coil by the manufacture approach of the thin film magnetic head by this invention in the field in which the 1st insulating layer is formed.
[0053] furthermore, by the manufacture approach of the thin film magnetic head by this invention After carrying out flattening of the 2nd insulating layer, a record gap layer is formed on the 2nd insulating layer. After forming the 2nd magnetic pole on a record gap layer, the 3rd insulating layer is formed on a record gap layer at least. Then, the thin film coil of at least one layer is formed on the 3rd insulating

layer on a record gap layer, and you may make it cover a thin film coil continuously by other different insulating layers from the 1st thru/or the 3rd insulating layer.
[0054] moreover, by the manufacture approach of the thin film magnetic head by this invention After forming other insulating layers with an inorganic system ingredient, flattening of other insulating layers is carried out so that the front face may form the same field as the front face of the 2nd magnetic pole. Then, after making it form the 2nd magnetic layer on the 2nd magnetic pole and other insulating layers by which flattening was carried out or forming other insulating layers alternatively with an organic system ingredient, you may make it form the 2nd magnetic layer on the 2nd magnetic pole and other insulating layers.
[0055] Furthermore, you may make it include the process which forms the magneto-resistive effect component for read-out by the manufacture approach of the thin film magnetic head by this invention.
[0056]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained to a detail with reference to a drawing.
[0057] [Gestalt of the 1st operation] Drawing 1 (a), (b), or drawing 7 (a) and (b) express the production process of the compound-die thin film magnetic head as the thin film magnetic head concerning the gestalt of operation of the 1st of this invention, respectively. In addition, in drawing 1 thru/or drawing 7 , (a) shows a cross section perpendicular to a truck side (ABS), and (b) shows the cross section parallel to the truck side of a magnetic pole part, respectively.
[0058] First, the configuration of the compound-die thin film magnetic head which starts the gestalt of this operation with reference to drawing 7 (a) and (b) is explained. This magnetic head has magneto-resistive effect read-out head section (henceforth the reproducing-head section) 1A for playback, and inductive recording head section (henceforth the recording head section) 1B for record.
[0059] Reproducing-head section 1A forms the pattern of the magneto-resistive effect film (henceforth MR film) 15 through the insulating layer [14] 12 13 formed with the alumina (an aluminum oxide and aluminum 2O3), for example, the lower shielding layer formed of iron silicide aluminum (FeAlSi), for example, the shielding gap layer formed with the alumina, one by one for example, on the substrate 11 which consists of ARUTIKKU (aluminum 2O3 and TiC). Moreover, on the shielding gap layer 14, lead terminal layer 15a formed with the ingredient which is not diffused on MR film, such as a tantalum (Ta) and a tungsten (W), is also formed, and this lead terminal layer 15a is electrically connected to the MR film 15. The MR film 15 is formed with the various ingredients which have magneto-resistive effects, such as for example, a permalloy (NiFe alloy), a (Nickel nickel)-cobalt (Co) alloy, etc. On the MR film 15 and lead terminal layer 15a, the laminating of the shielding gap layer 17 which consists of an alumina is carried out. That is, the MR film 15 and lead terminal layer 15a are laid underground between the shielding gap layer 14 and 17. In addition, especially the MR film 15 may not be limited and the AMR film, the GMR film or other magneto-resistive effect film, etc. are sufficient as it.
[0060] Recording head section 1B forms an up magnetic pole on this reproducing-head section 1A through the lower magnetic pole and the record gap layer 22 which serve as the up shielding layer to the MR film 15.
[0061] With the gestalt of this operation, a lower magnetic pole is divided into the lower magnetic pole layer (lower pole) 18 formed on the shielding gap layer 17, and lower magnetic pole point (lower pole chip) 19a formed on the lower magnetic pole layer 18 at the truck side side two, and is formed in it. Up magnetic pole point (up pole chip) 23a which similarly 2 ****s also of up magnetic poles are carried out, and was formed by carrying out the record gap layer 22 in between on lower magnetic pole point 19a at the truck side side, It is constituted by the up magnetic pole layer (up pole) 25 which was formed along the top face of the apex section containing the below-mentioned coil and which serves as the York section while contacting section magnetic pole point 23a besides. The up magnetic pole layer 25 is magnetically combined with the lower magnetic pole layer 18 through up connection 23b and lower connection 19b in the location (it sets to drawing 7 (a) and is right-hand side) of the truck side of the apex section, and the opposite side.
[0062] The width of face of up connection 23b differs from the width of face of lower connection 19b,

namely, area differs and the area of up connection 23b is larger than the area of lower connection 19b with the gestalt of this operation. Moreover, lower connection 19b touches the mid gear of up connection 23b, and, thereby, the flow of the magnetic flux from the up magnetic pole layer 25 to the lower magnetic pole layer 18 becomes smooth.

[0063] The above lower magnetic pole layer 18, lower magnetic pole point 19a, lower connection 19b, up magnetic pole point 23a, up connection 23b, and the up magnetic pole layer 25 are formed of for example, a high saturation-magnetic-flux-density ingredient (Hi-Bs material) (nickel:50 % of the weight, Fe:50 % of the weight), for example, NiFe, NiFe (nickel:80 % of the weight, Fe:20 % of the weight), FeN, FeZrNP, CoFeN, etc., respectively.

[0064] In this recording head section 1B, lower magnetic pole magnetic pole point 19a which counters up magnetic pole point 23a has trim (Trim) structure which processed a part of that surface part in the shape of **. Thereby, in the time of the writing of effective write-in truck broadening, i.e., data, the breadth of the magnetic flux in a lower magnetic pole is controlled.

[0065] In addition, in the gestalt of this operation, the 1st magnetic layer of this invention and lower magnetic pole point 19a correspond [the lower magnetic pole layer 18] to the 1st magnetic pole of this invention, respectively, and the 2nd magnetic pole of this invention and the up magnetic pole layer 25 are equivalent to the 2nd magnetic layer of this invention for up magnetic pole point 23a, respectively.

[0066] With the gestalt of this operation, the thin film coil 21 of the 1st layer is formed in the crevice field between lower magnetic pole point 19a on the lower magnetic pole layer 18, and lower connection 19b. That is, insulating-layer 20a is formed in the internal surface (a base and side-attachment-wall side) of a crevice field, and the thin film coil 21 is formed on this insulating-layer 20a. It is embedded by insulating-layer 20b between the coils of the thin film coil 21, and flattening is carried out so that the front face of this insulating-layer 20b and the front face of lower magnetic pole point 19a may constitute the same side. Therefore, the level difference of the apex section in which only the part of this thin film coil 21 contains the below-mentioned thin film coil 24 is low. In addition, the 1st insulating layer of this invention and insulating-layer 20b support [insulating-layer 20a] the 2nd insulating layer of this invention, respectively.

[0067] The record gap layer 22 has extended on insulating-layer 20b by which flattening was carried out, and the thin film coil 21. Insulating-layer 20c is formed in the crevice field between up magnetic pole point 23a on this record gap layer 22, and up connection 23b. The thin film coil 24 of a two-layer eye is formed on this insulating-layer 20c. This thin film coil 24 is covered with 20d of insulating layers which consist of an alumina. 20d of this insulating layer supports other insulating layers of this invention.

[0068] On 20d of insulating layers, the up magnetic pole layer 25 which serves as the York section is formed. The up magnetic pole layer 25 is covered with the overcoat layer 26. In addition, although not illustrated, the thin film coils 21 and 24 are electrically connected with insulating-layer 20b in the 20d [of insulating layers] interface.

[0069] While read-out of information is performed from the magnetic disk which is not illustrated using the magneto-resistive effect of the MR film 15, in this magnetic head, information is written in to a magnetic disk in recording head section 1B in reproducing-head section 1A using change of the magnetic flux between up magnetic pole point 23a and lower magnetic pole point 19a with the thin film coils 21 and 24.

[0070] Next, the manufacture approach of the above-mentioned compound-die thin film magnetic head is explained.

[0071] In the manufacture approach concerning the gestalt of this operation, first, as shown in drawing 1 , the insulating layer 12 which consists of an alumina (aluminum 2O3) is formed by the thickness of about about 3-5 micrometers by the spatter on the substrate 11 which consists of ARUTIKKU (aluminum 2O3 and TiC). Next, on an insulating layer 12, by using the photoresist film as a mask, a permalloy (NiFe) is alternatively formed by the thickness of about 3 micrometers, and the lower shielding layer 13 for the reproducing heads is formed by the galvanizing method. then, a spatter or CVD (Chemical Vapor Deposition) -- the alumina film (not shown) with a thickness of about 4-6

micrometers is formed by law, and flattening is carried out by CMP.
[0072] Next, as shown in drawing 2 , on the lower shielding layer 13, an alumina is deposited by the spatter by the thickness of 100-200nm, and the shielding gap layer 14 is formed. Then, on the shielding gap layer 14, the MR film 15 for constituting MR component for playback etc. is formed at the thickness of dozens of nm, and is made into a desired configuration by the highly precise photolithography. Then, lead terminal layer 15a to this MR film 15 is formed by the lift-off method. Subsequently, the shielding gap layer 17 is formed on the shielding gap layer 14, the MR film 15, and lead terminal layer 15a, and the MR film 15 and lead terminal layer 15a are laid underground in the shielding gap layer 14 and 17.
[0073] Then, the lower magnetic pole layer (lower pole) 18 which served as up shielding which consists of a permalloy (NiFe) is formed by the thickness of about 1.0-1.5 micrometers on the shielding gap film 17.
[0074] Next, as shown in drawing 3 , lower magnetic pole point (lower pole chip) 19a and lower connection 19b are formed by the thickness of about 2.0-2.5 micrometers on the lower magnetic pole layer 18. Lower magnetic pole point 19a is fabricated so that the point by the side of the truck may come near the location of MR (GMR) height zero, and it is made for the opposite side of a truck side to serve as a location of throat height zero here at coincidence. In addition, this lower magnetic pole point 19a and lower connection 19b may be formed with plating film, such as NiFe, as mentioned above, and may be formed with spatter film, such as FeN, FeZrNP, and CoFeN.
[0075] Then, insulating-layer of 0.3-0.6 micrometers of thickness which consists of insulating material, for example, alumina, with spatter or CVD method 20a is formed in the whole surface.
[0076] Next, as shown in drawing 4 , the thin film coil 21 of the 1st layer for the recording heads of the induction type which consists of copper (Cu) is formed in the crevice field formed between lower magnetic pole point 19a and lower connection 19b by the thickness of 1.5-2.5 micrometers for example, by the electrolysis galvanizing method.
[0077] Next, as shown in drawing 5 , after forming in the whole surface insulating-layer of 3.0-4.0 micrometers of thickness which consists of insulating material, for example, alumina, by spatter 20b, flattening of the front face is carried out by the CMP method, and the front face of lower magnetic pole point 19a is exposed. Although the front face of the thin film coil 21 is also exposed to coincidence with the gestalt of this operation at this time, it is not necessary to expose surface parts other than a connection with the thin film coil 24 of the two-layer eye which the thin film coil 21 mentions later.
[0078] Next, as shown in drawing 6 , the record gap layer 22 of 0.2-0.3 micrometers of thickness which consists of an insulating material, for example, an alumina, by the spatter is formed. You may make it form the record gap layer 22 with the ingredient of alumimium nitride (AlN) besides an alumina, a silicon oxide system, and a silicon nitride system etc. Then, patterning of this record gap layer 22 is carried out with photolithography, and opening 22a for connection between an up magnetic pole and a lower magnetic pole is formed.
[0079] Then, up magnetic pole point (pole chip) 23a for determining the width of recording track of a recording head is formed with photolithography on the record gap layer 22. That is, the magnetic pole layer of 2.5-3.5 micrometers of thickness which consists of a high saturation-magnetic-flux-density ingredient (Hi-Bs material) (nickel:50 % of the weight, Fe:50 % of the weight), for example, NiFe, NiFe (nickel:80 % of the weight, Fe:20 % of the weight), FeN, FeZrNP, CoFeN, etc. by the spatter is formed on the record gap layer 22. Then, up connection 23b for [which used the photoresist mask for this magnetic pole layer] connecting an up magnetic pole and a lower magnetic pole magnetically, while removing alternatively and forming up magnetic pole point 23a, for example by the ion milling of Ar (argon) is formed. You may make it etch up magnetic pole point 23a and up connection 23b instead of a photoresist mask using the mask by inorganic system insulating layers, such as an alumina, they are not based on such photolithography, in addition you may make it form them by the galvanizing method, a spatter, etc.
[0080] While forming up magnetic pole point 23a in a back side from a truck side for a long time than lower magnetic pole point 19a, up connection 23b is formed more broadly than lower connection 19b, and it is made for lower connection 19b to be contacted by the mid gear of up connection 23b with the

gestalt of this operation here.
[0081] Then, the record gap layer 22 of the circumference of it and lower magnetic pole point 19a are etched in self align by using up magnetic pole point 23a as a mask. Namely, RIE by the chlorine-based gas (Cl2, CF4, BCl2, SF6, etc.) which used up magnetic pole point 23a as the mask (Reactive Ion Etching) After removing the record gap layer 22 alternatively, exposed about about 0.3-0.6 micrometers lower magnetic pole point 19a is again etched by the ion milling of Ar, and the recording track of trim structure is formed.
[0082] Then, insulating-layer 20c which consists of an alumina of about 0.3-0.6 micrometers of thickness is formed in the whole surface with a spatter or a CVD method. Then, the thin film coil 24 of the two-layer eye for the recording heads of the induction type which consists of copper (Cu) is formed by the thickness of 1.5-2.5 micrometers for example, by the electrolysis galvanizing method on this insulating-layer 20c.
[0083] Then, 20d of insulating layers of about 3-4 micrometers of thickness which consist of an alumina is formed in the whole surface with a spatter or a CVD method. In addition, 20d of this insulating layer and insulating-layer 20c may be formed by other insulating materials, such as not only an alumina but a silicon dioxide (SiO2), and silicon nitride (SiN). Then, by the CMP method, 20d of insulating layers and insulating-layer 20c are etched so that the front face of up magnetic pole point 23a and up connection 23b may be exposed, and flattening is carried out, for example so that each front face of an insulating layers [20c and 20d] front face, up magnetic pole point 23a, and up connection 23b may constitute the same side.
[0084] Next, as shown in drawing 7 , the up magnetic pole layer 25 is formed in the thickness of about 3-4 micrometers by approaches, such as the electrolysis galvanizing method and a spatter, using the same ingredient as up magnetic pole point 23a. Besides, the section magnetic pole layer 25 is seen from a truck side side, in a back location, through up connection 23b, contacts lower connection 19b and is magnetically connected with the lower magnetic layer 18 rather than the thin film coils 21 and 24. Finally, the overcoat layer 26 of about 30 micrometers of thickness which consists of an alumina by the spatter is formed on the up magnetic pole layer 25. Then, the thin film magnetic head is completed by machining a slider and forming the truck side (ABS) of a recording head and the reproducing head.
[0085] In addition, drawing 8 is the top view of the thin film magnetic head concerning the gestalt of this operation. In addition, this drawing expresses the condition before machining a slider. In these drawings, TH expresses throat height and this throat height TH is specified by the edge by the side of the magnetic pole part of insulating-layer 20a, i.e., the edge of the truck side of lower magnetic pole point 19a, and the opposite side. In this drawing, since the throat height TH is in agreement with GMR height, it turns into TH=GMR height. In addition, one edge of lead terminal 21a is connected to the thin film coil 21. The other-end section of this lead terminal 21a is connected to the pad section for electrode drawers (not shown). Moreover, the other-end section of lead terminal layer 15a connected to the MR component 15 is also the same, and one edge is connected to the pad section for electrode drawers (not shown).
[0086] The following effectiveness can be acquired with the gestalt of this above operation.
[0087] (1) First, with the gestalt of this operation, since a lower magnetic pole is divided into two at lower magnetic pole point 19a and the lower magnetic pole layer 18 and lower magnetic pole point 19a was formed on the flat side of the lower magnetic pole layer 18, the insulating layers 20a and 20b which consist of an inorganic material can be embedded in the crevice between lower magnetic pole point 19a and lower connection 19b. Therefore, throat height is prescribed by the edge by the side of lower magnetic pole point 19a of insulating-layer 20a (namely, edge of the truck side of lower magnetic pole point 19a, and the opposite side). Therefore, like the conventional photoresist film, location fluctuation (pattern shift) and profile aggravation of the edge do not arise, and exact control of throat height is attained. Furthermore, exact control of MR height and exact control of an apex angle type also become possible.
[0088] (2) Moreover, with the gestalt of this operation, since up magnetic pole point 23a was formed for a long time than lower magnetic pole point 19a, compared with the case where up magnetic pole point

23a is made into the same die length as lower magnetic pole point 19a, the touch area of up magnetic pole point 23a and the up magnetic pole layer 25 can be enlarged, and magnetic association in the part becomes good. Such a configuration is effective when it considers as the structure (recess structure) of forming the up magnetic pole layer 25 in the location which retreated from the truck side like the gestalt of this operation especially. That is, if the up magnetic pole layer 25 exists in the location near [location / (edge of the truck side of lower magnetic pole point 19a, and the opposite side) / of throat height TH= zero] a truck side side, for example, the TH=0.5micrometer near location, the poor side light which writes information in the truck which adjoins by the up magnetic pole layer 25 will be generated. Ideally, as for the up magnetic pole layer 25, it is desirable for TH to form in the location more distant than the location of zero from a truck side. On the other hand, it is necessary to combine magnetically lower magnetic pole point 19a for deciding TH with the up magnetic pole layer 25 through up magnetic pole point 23a, and TH needs to connect firmly up magnetic pole point 23a and the up magnetic pole layer 25 in a truck side and an opposite direction from the location of zero with the gestalt of this operation. Since it is such, as for up magnetic pole point 23a, it is desirable to form for a long time than lower magnetic pole point 19a.

[0089] (3) Moreover, since width of face of lower magnetic pole point 19a is made larger than the width of face of up magnetic pole point 23a when each pattern is seen from right above as shown in drawing 8 , even if up magnetic pole point 23a is the ** truck of half micron width of face, magnetic flux is not saturated with the gestalt of this operation [near the lower magnetic pole point 19a].

[0090] In (4) and time, up magnetic pole point 23a and lower magnetic pole point 19a are made detailed, the width of face follows on becoming narrow, and the width of face of the contact section of an up magnetic pole and a lower magnetic pole, i.e., lower connection 19b, and up connection 23b also becomes narrow. Thus, when width of face of lower connection 19b and up connection 23b is made detailed and the include angle to the lower magnetic layer 18 of the side attachment wall of lower connection 19b or the include angle to the up magnetic layer 25 of the side attachment wall of up connection 23b is perpendicular respectively, there is a possibility that magnetic flux may be saturated in the part. On the other hand, with the gestalt of this operation, the area of up connection 23b is large rather than lower connection 19b, and moreover, since lower connection 19b has countered the center section of up connection 23b, when it sees in a cross section, the whole configuration which has the slope where the whole contact section met the inclined plane between up-and-down coils, i.e., the contact section, turns into a configuration just like a funnel. Therefore, the flow of the magnetic flux from an up magnetic pole to a lower magnetic pole becomes smooth, and magnetic association of both magnetic poles becomes good. in addition, up connection 23b and lower connection 19b -- respectively -- being also alike -- it is good also as a configuration which forms a taper, and the flow of the magnetic flux to a lower magnetic pole becomes smoother from an up magnetic pole by such configuration. Moreover, it is good also as a configuration to which the area by the side of lower connection 19b becomes larger than the area of up connection 23b conversely.

[0091] Furthermore with the gestalt of this operation, between the thin film coil 21 and the lower magnetic pole layer 18 which served both as up shielding, (5) The insulator layers 20a and 20b of an inorganic system, Between the thin film coil 21 and 24, the record gap film 22 and insulating-layer 20c are prepared. Moreover, a sake, By adjusting each insulating layer thickness, while being able to obtain respectively big withstand voltage between the thin film coils 21 and 24 and up shielding and being able to hold insulation to it, the leakage of the magnetic flux from the thin film coils 21 and 24 can be reduced.

[0092] (6) Moreover, with the gestalt of this operation, since an up magnetic pole is divided into two at up magnetic pole point 23a and the up magnetic pole layer 25 and up magnetic pole point 23a was formed in the flat side on lower magnetic pole point 19a, up magnetic pole point 23a which regulates recording track width of face can be formed with a precision sufficient in a submicron dimension. In addition, with the gestalt of this operation, while the thin film coil 21 of the 1st layer is embedded in the crevice field which adjoined lower magnetic pole point 19a by insulating-layer 20b, flattening of the front face of insulating-layer 20b is carried out to extent which forms the same field as the front face of

lower magnetic pole point 19a. That is, the level difference of the apex section containing the thin film coil 24 of a two-layer eye becomes low [part / of the thin film coil 21 of the 1st layer / conventionally / structure]. Therefore, in case the up magnetic pole layer 25 which contacts up magnetic pole point 23a partially is formed with photolithography, it becomes possible to reduce the difference of the thickness of the photoresist film in the upper part and the lower part of the apex section, consequently to attain detailed-ization of the submicron dimension of the up magnetic pole layer 25. Therefore, in the thin film magnetic head obtained according to the gestalt of this operation, the high surface density record by the recording head can be attained, the laminating of the coil can be carried out to two-layer and three layers, and the engine performance of a recording head can be raised further. In addition, it becomes possible by using an inorganic system insulating layer as a mask instead of a photoresist in the case of the photolithography of up magnetic pole point 23a and the up magnetic pole layer 25 to realize more detailed-ization of up magnetic pole point 23a and the up magnetic pole layer 25 to high degree of accuracy. Moreover, similarly, when forming up magnetic pole point 23a and the up magnetic pole layer 25 by spatters other than photolithography etc., since the effect of the level difference of the apex section is reduced, detailed-ization of up magnetic pole point 23a and the up magnetic pole layer 25 can be attained.

[0093] (7) Furthermore, with the gestalt of this operation, since the ramp of a photoresist pattern does not exist like the conventional example, both the 1st and the thin film coils 21 and 24 of the 2nd layer can be formed in a flat part, and, as for the hindrance of magnetic-path length contraction, the distance to the location of the periphery edge outside a coil by the ramp and throat height zero does not become. Therefore, with the gestalt of this operation, magnetic-path length can be shortened and the RF property of a recording head can be raised remarkably. Incidentally, with the gestalt of this operation, since it can design by 0.1micrometer-.0.2micrometer of the alignment error of photolithography, it becomes possible to reduce magnetic-path length to 50% or less of the conventional example.

[0094] (8) Moreover, without saturating with the gestalt of this operation the MAG generated in the thin film coils 21 and 24 on the way, even if the width of recording track becomes narrow since the magnetic layer of up magnetic pole point 23a and up magnetic pole layer 25 grade is formed of high saturation-magnetic-flux-density (Hi-Bs) material, up magnetic pole point 23a and lower magnetic pole point 19a are reached effectively, and this can realize a recording head without magnetic loss.

[0095] (9) Furthermore, with the gestalt of this operation, since the up magnetic pole layer 25 formed on up magnetic pole point 23a which determines the width of recording track is not exposed to a truck side, the side light by the up magnetic pole layer 25 is not generated.

[0096] (10) Moreover, with the gestalt of this operation, since it is thinner than the up magnetic pole layer 25, even if much magnetic flux flows [up magnetic pole point 23a which determines the width of recording track] from the up magnetic pole layer 25, since the distance between the up magnetic pole layer 25 and the record gap layer 22 is short, it is lost that magnetic flux is saturated in this part, and an over-writing (overwrite) property and a nonlinear transition (NLTS) property improve.

[0097] Hereafter, the gestalt of other operations of this invention is explained. In addition, by the following explanation, the sign same about the same component as the gestalt of the 1st operation is attached, the explanation is omitted, and only a different part is explained.

[0098] [Gestalt of the 2nd operation] Drawing 9 (a) and (b) express the configuration of the compound-die thin film magnetic head concerning the gestalt of operation of the 2nd of this invention. Although the thin film coil 24 of the 2nd layer was made into the structure completely embedded below the front face of up magnetic pole point 23a (i.e., the inside of 20d of insulating layers by which flattening was carried out) with the gestalt of the 1st operation, when thin, in flattening processes, such as CMP, the front face of the thin film coil 24 may be exposed for up magnetic pole point 23a. With the gestalt of this operation, in order to secure the insulation between the thin film coil 24 and the up magnetic pole layer 25 in such a case, the insulating layer 30 by the photoresist of 1.0 micrometers of thickness is alternatively formed between the thin film coil 24 and the up magnetic pole layer 25. Since the other configurations and operation effectiveness are the same as the gestalt of the 1st operation, the explanation is omitted.

[0099] [Gestalt of the 3rd operation] As shown in drawing 10 (a), (b), and (c), the process which forms the thin film coil 24 of a two-layer eye is the same as the gestalt of the 1st operation, but after that, the gestalt of this operation covers the thin film coil 24 with the photoresist film 31, then it forms it so that that point may not expose the up magnetic pole layer 25 to a truck side on this photoresist film 31. In addition, this drawing (c) is a top view taking out and showing lower magnetic pole point 19a of this drawing (a) and the (b), lower connection 19b, up magnetic pole point 23a, lower connection 23b, and the up magnetic pole layer 25.

[0100] With the gestalt of this operation, unlike the gestalt of the 1st operation, after forming the thin film coil 24 of a two-layer eye, flattening by CMP does not need to carry out. Therefore, a manufacturing cost is reduced compared with the part and the gestalt of the 1st operation. In addition, since it is formed in the part to which the thin film coil 24 of a two-layer eye was made into five volumes, and flattening of the thin film coil 21 of the 1st layer of six volumes was carried out, the distance from the periphery edge of the thin film coil 24 to the location of throat height zero does not serve as hindrance of magnetic-path length. Since the other configurations and operation effectiveness are the same as the gestalt of the 1st operation, the explanation is omitted.

[0101] Although the gestalt of operation was mentioned above and this invention was explained, this invention is not limited to the gestalt of the above-mentioned implementation, and is variously deformable. For example, in the gestalt of the above-mentioned implementation, although up magnetic pole point 23a and up magnetic pole layer 25 grade explained the example which uses high saturation-magnetic-flux-density material, such as FeN besides NiFe (nickel:50 % of the weight, Fe:50 % of the weight) and NiFe (nickel:80 % of the weight, Fe:20 % of the weight), and FeCoZr, they are good also as structure which carried out the two or more kind laminating of these ingredients.

[0102] Moreover, although the thin film coil embedded in the crevice adjoined and formed in lower magnetic pole point 19a was made into one layer with the gestalt of the 1st thru/or the 5th operation, it is good also as a laminated structure embedding the coil more than two-layer.

[0103] Furthermore, although the side attachment wall made the perpendicular configuration lower magnetic pole point 19a to the lower magnetic pole layer 18, you may make it prepare the inclined plane (taper) of about theta= 50 - 70 degrees with the gestalt of the above-mentioned implementation, corresponding to the thickness of a coil. By considering as such a configuration, the saturation of the magnetic flux in the connection of the lower magnetic pole layer 18 and lower magnetic pole point 19a is controlled, and the flow of magnetic flux becomes smooth.

[0104] Moreover, although the gestalt of the above-mentioned implementation explained the structure (recess structure) which forms the up magnetic pole layer 25 in the location which retreated from the truck side, it is good also as structure of exposing the up magnetic pole layer 25 to a truck side with up magnetic pole point 23a, by thickening thickness of the up magnetic pole layer 25 relatively rather than up magnetic pole point 23a. Even if it does not consider as recess structure by this, the fault which a side light generates by the up magnetic pole layer 25 is cancelable.

[0105] Furthermore, although considered as the structure which embeds the thin film coil of the 1st layer by the insulating layer with the gestalt of the above-mentioned implementation in the crevice field which adjoined lower magnetic pole point 19a, it may be made to make the whole crevice field into the insulating layer of the inorganic system which consists of an alumina, without embedding a thin film coil. In addition, although the gestalt of the above-mentioned implementation showed the configuration whose up magnetic pole was made, respectively corresponding to [magnetic layer / 2nd] corresponding to the 1st magnetic layer for a lower magnetic pole, the configuration which made this correspondence reverse is also possible. That is, it is good also as a configuration whose up magnetic pole was made, respectively corresponding to [magnetic layer / 1st] corresponding to the 2nd magnetic layer for a lower magnetic pole.

[0106] Moreover, with the gestalt of each above-mentioned implementation, although the manufacture approach of the compound-die thin film magnetic head was explained, this invention is applicable also to the manufacture of the thin film magnetic head only for records, or the thin film magnetic head of record / playback combination which has an induction type MAG sensing element for writing.

Moreover, this invention can also be applied also to manufacture of the thin film magnetic head of the structure which replaced the sequence of the laminating of the component for writing, and the component for playback.

[0107]

[Effect of the Invention] Since it was formed in the shape of ** on the 1st magnetic pole layer according to the manufacture approach of the thin film magnetic head concerning this invention, or the thin film magnetic head concerning this invention while dividing the 1st magnetic pole with the 1st magnetic pole layer as explained above, the insulating layer which consists of an inorganic material can be embedded in the crevice which adjoined the 1st magnetic pole. Therefore, by the edge of the truck side of the 1st magnetic pole, and the opposite side, throat height is specified, location fluctuation and profile aggravation of the edge do not arise like the conventional photoresist film, and the effectiveness that exact control of throat height is attained is done so. Moreover, since the 2nd magnetic pole which counters the 1st magnetic pole is also divided with the 2nd magnetic pole layer and formed this 2nd magnetic pole in the back side for a long time from the truck side rather than the 1st magnetic pole While being able to carry out [detailed]-izing of the 2nd magnetic pole to a submicron dimension, the flow of the increase of the touch area of the 2nd magnetic pole and the 2nd magnetic layer and magnetic flux becomes smooth, and the highly precise thin film magnetic head can be conjointly realized with exact control of the above-mentioned slow height.

[0108] Moreover, if a thin film coil is embedded in the crevice which adjoined the 1st magnetic pole Compared with structure, can make low conventionally the level difference of the part and the apex section, and it sets at a subsequent process. In case the 2nd magnetic layer is formed with photolithography, it becomes possible to reduce the difference of the thickness of the photoresist film in the upper part and the lower part of the apex section, consequently to attain detailed-ization of the submicron dimension of the 2nd magnetic layer. Therefore, the high surface density record by the recording head is attained, and it becomes possible by carrying out the laminating of the coil to two-layer and three layers to raise the engine performance of a recording head further.

[Translation done.]

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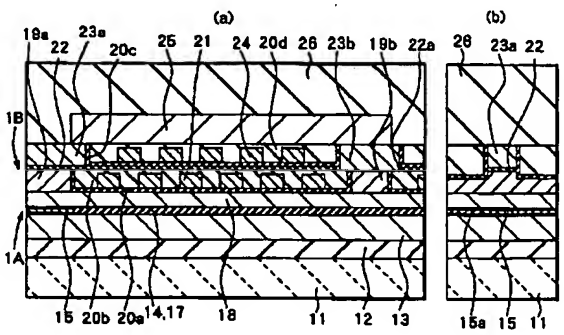
(54)【発明の名称】　薄膜磁気ヘッドおよびその製造方法

(57)【要約】
【課題】　記録ヘッドのスロートハイトを正確に制御できる薄膜磁気ヘッドを提供する。
【解決手段】　記録ヘッドの下部磁極を、下部磁極先端部１９ａと下部磁極層１８とに２分割し、下部磁極先端部１９ａを下部磁極層１８の平坦面上に突状に形成する。１層目の薄膜コイル２１と共に無機材料からなる絶縁層２０ａ，２０ｂを、下部磁極先端部１９ａと下部接続部１９ｂとの間の凹部内に埋め込む。絶縁層２０ａの下部磁極先端部１９ａ側の端縁（すなわち下部磁極先端部１９ａのトラック面と反対側の端縁）によってスロートハイトが規定される。従って、従来のフォトレジスト膜のように、端縁の位置変動（パターンシフト）およびプロファイル悪化が生じることがなく、スロートハイトの正確な制御が可能になる。また、上部磁極先端部２３ａのトラック面からの長さが下部磁極先端部１９ａよりも長くなっており、その分、上部磁極先端部２３ａと上部磁極層２５との接触面積が広くなる。



【特許請求の範囲】

【請求項１】　磁気的に連結され、且つ記録媒体に対向する側の一部が記録ギャップ層を介して対向する第１の磁極および第２の磁極を含む少なくとも２つの磁性層と、磁束を発生させるための１層あるいは２層以上の薄膜コイルとを有する薄膜磁気ヘッドであって、

第１の磁性層と、

この第１の磁性層と分割して形成されると共に、前記記録ギャップ面との隣接面の反対側の面が、前記第１の磁性層の一部領域に磁気的に結合された第１の磁極と、

無機系材料に形成されると共に、少なくとも前記第１の磁極の前記記録媒体に対向する側の反対面から前記第１の磁性層の一方の面に連続的に形成された絶縁層と、

前記記録ギャップ層を介して前記第１の磁極に対向すると共に、前記記録媒体に対向する面から奥側に向けて前記第１の磁極よりも長く形成された第２の磁極と、

この第２の磁極と分割して形成されると共に、前記第２の磁極の前記記録ギャップ面との隣接面の反対側の面の少なくとも一部において前記第２の磁極に磁気的に結合された第２の磁性層とを備えたことを特徴とする薄膜磁気ヘッド。

【請求項２】　前記第１の磁極の前記記録媒体に対向する面からの長さが記録ヘッドのスロートハイトに等しいことを特徴とする請求項１記載の薄膜磁気ヘッド。

【請求項３】　前記第２の磁極は、前記第１の磁極よりも前記第２の磁極の膜厚相当分だけ長いことを特徴とする請求項１または２に記載の薄膜磁気ヘッド。

【請求項４】　少なくとも一層の薄膜コイルが、少なくともその膜厚方向の一部が前記絶縁層が形成されている領域内に位置するように形成されていることを特徴とする請求項１乃至３のいずれか１項に記載の薄膜磁気ヘッド。

【請求項５】　前記絶縁層は、前記第１の磁極の前記記録媒体に対向する側の反対面から前記第１の磁性層の一方の面に沿って連続的に形成された第１の絶縁層と、少なくとも、前記薄膜コイルの巻線間に形成された第２の絶縁層とを含むことを特徴とする請求項４に記載の薄膜磁気ヘッド。

【請求項６】　前記絶縁層の前記第１の磁性層との隣接面の反対面が、前記第１の磁極の前記記録ギャップ層との隣接面の反対面と実質的に同一面となるように形成されていることを特徴とする請求項１乃至３のいずれか１項に記載の薄膜磁気ヘッド。

【請求項７】　前記第１の磁極の前記記録媒体に対向する面に沿った幅が前記第２の磁極の幅よりも広く形成されていることを特徴とする請求項６に記載の薄膜磁気ヘッド。

【請求項８】　更に、前記第２の磁性層の前記記録媒体に対向する側と反対側の端部近傍において、前記第１の磁性層に隣接して形成された第１の接続部と、この第１の接続部に対向する位置において前記第２の磁性層に隣接して形成された第２の接続部とを備え、且つ、前記第１の接続部および前記第２の接続部それぞれの互いに対向する側の面積が異なることを特徴とする請求項１乃至７のいずれか１項に記載の薄膜磁気ヘッド。

【請求項９】　前記第２の接続部の面積が前記第１の接続部のそれよりも広いことを特徴とする請求項８に記載の薄膜磁気ヘッド。

【請求項１０】　前記第２の磁性層の前記記録媒体に対向する面側の端部は、前記記録媒体に対向する面から後退した位置に形成されていることを特徴とする請求項１乃至９のいずれか１項に記載の薄膜磁気ヘッド。

【請求項１１】　前記第１の絶縁層は、更に、前記第１の磁極の前記記録媒体に対向する側の端面を除く両側面に沿って形成されていることを特徴とする請求項５乃至９のいずれか１項に記載の薄膜磁気ヘッド。

【請求項１２】　前記薄膜コイルの膜厚方向の全部が、前記第１の絶縁層が形成されている領域内に形成されていることを特徴とする請求項５乃至１０のいずれか１項に記載の薄膜磁気ヘッド。

【請求項１３】　前記第２の絶縁層が、前記第１の磁極の前記記録ギャップ層との隣接面と実質的に同一面となるように形成されていることを特徴とする請求項１２に記載の薄膜磁気ヘッド。

【請求項１４】　前記記録ギャップ層の一方の面が前記第２の絶縁層を覆うように形成されていることを特徴とする請求項１３に記載の薄膜磁気ヘッド。

【請求項１５】　更に、第３の絶縁層が、少なくとも、前記第２の磁極の前記記録媒体に対向する側の反対面から前記記録ギャップ層の他方の面にかけて連続的に形成されていることを特徴とする請求項１４に記載の薄膜磁気ヘッド。

【請求項１６】　前記第３の絶縁層と前記第２の磁性層との間に、更に、前記第１ないし第３の絶縁層とは異なる他の絶縁層に覆われて形成された少なくとも１層の薄膜コイルを備えていることを特徴とする請求項１５に記載の薄膜磁気ヘッド。

【請求項１７】　前記第３の絶縁層および他の絶縁層が、前記第２の磁極の前記記録ギャップ層との隣接面の反対面と実質的に同一面となるように形成されていることを特徴とする請求項１６に記載の薄膜磁気ヘッド。

【請求項１８】　更に、読み出し用の磁気抵抗効果素子を備えたことを特徴とする請求項１乃至１７のいずれか１項に記載の薄膜磁気ヘッド。

【請求項１９】　磁気的に連結され、且つ記録媒体に対向する側の一部が記録ギャップ層を介して対向する第１の磁極および第２の磁極を含む少なくとも２つの磁性層と、磁束を発生させるための１層あるいは２層以上の薄膜コイルとを有する薄膜磁気ヘッドの製造方法であって、

第１の磁性層を形成した後、前記第１の磁性層の上に、前記第１の磁性層の一部領域と磁気的に結合されるように第１の磁極を形成する工程と、
少なくとも前記第１の磁極の前記記録媒体に対向する側の反対面から前記第１の磁性層の一方の面にかけて無機系材料からなる絶縁層を連続的に形成する工程と、
少なくとも前記第１の磁極の上に記録ギャップ層を形成した後、前記第２の磁極を、前記記録媒体に対向する面から奥側に向けて前記第１の磁極よりも長く形成する工程と、
前記第２の磁極に磁気的に結合させて第２の磁性層を形成する工程とを含むことを特徴とする薄膜磁気ヘッドの製造方法。

【請求項２０】　更に、前記第１の磁極を形成すると同時に、前記第２の磁性層の前記記録媒体に対向する側と反対側の端部近傍の位置において、前記第１の磁性層に隣接して第１の接続部を形成すると共に、前記第２の磁極を形成すると同時に、前記第２の磁性層の前記記録媒体に対向する側と反対側の端部近傍の位置において、前記第２の磁性層に隣接して、前記第１の接続部と異なる面積の第２の接続部を形成することを特徴とする請求項１９に記載の薄膜磁気ヘッドの製造方法。

【請求項２１】　少なくとも一層の薄膜コイルを、少なくともその膜厚方向の一部が前記絶縁層が形成されている領域内に位置するように形成する工程を含むことを特徴とする請求項１９または２０に記載の薄膜磁気ヘッドの製造方法。

【請求項２２】　前記第１の磁極の前記記録媒体に対向する側の反対面から前記第１の磁性層の一方の面に沿って連続的に第１の絶縁層を形成する工程と、少なくとも前記薄膜コイルの巻線間に第２の絶縁層を形成する工程とを含むことを特徴とする請求項２１に記載の薄膜磁気ヘッドの製造方法。

【請求項２３】　前記第２の絶縁層の前記第１の磁性層との隣接面の反対面が、前記第１の磁極の前記記録ギャップ層との隣接面の反対面と実質的に同一面となるように平坦化する工程を含むことを特徴とする請求項２２に記載の薄膜磁気ヘッドの製造方法。

【請求項２４】　前記第１の磁極の前記記録媒体に対向する面に沿った幅を前記第２の磁極よりも広く形成することを特徴とする請求項１９乃至２３のいずれか１項に記載の薄膜磁気ヘッドの製造方法。

【請求項２５】　前記薄膜コイルの膜厚方向の全部を、前記第１の絶縁層が形成されている領域内に形成することを特徴とする請求項１９乃至２４のいずれか１項に記載の薄膜磁気ヘッドの製造方法。

【請求項２６】　前記第２の絶縁層を平坦化した後、前記第２の絶縁層上に記録ギャップ層を形成し、前記記録ギャップ層上に前記第２の磁極を形成した後、少なくとも前記記録ギャップ層上に第３の絶縁層を形成し、その後、前記記録ギャップ層上の前記第３の絶縁層の上に少なくとも１層の薄膜コイルを形成し、続いて前記薄膜コイルを前記第１乃至第３の絶縁層とは異なる他の絶縁層により覆うことを特徴とする請求項２５に記載の薄膜磁気ヘッドの製造方法。

【請求項２７】　前記他の絶縁層を無機系材料により形成した後、前記他の絶縁層を、その表面が前記第２の磁極の表面と同一面を形成するように平坦化し、その後、前記第２の磁極および平坦化された他の絶縁層上に前記第２の磁性層を形成することを特徴とする請求項２６に記載の薄膜磁気ヘッドの製造方法。

【請求項２８】　前記他の絶縁層を有機系材料により選択的に形成した後、前記第２の磁極および他の絶縁層上に前記第２の磁性層を形成することを特徴とする請求項２７に記載の薄膜磁気ヘッドの製造方法。

【請求項２９】　更に、読み出し用の磁気抵抗効果素子を形成する工程を含むことを特徴とする請求項１９乃至２８のいずれか１項に記載の薄膜磁気ヘッドの製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、少なくとも書き込み用の誘導型磁気変換素子を有する薄膜磁気ヘッドおよび薄膜磁気ヘッドの製造方法に関する。

【０００２】

【従来の技術】近年、ハードディスク装置の面記録密度の向上に伴って、薄膜磁気ヘッドの性能向上が求められている。薄膜磁気ヘッドとしては、書き込み用の誘導型磁気変換素子を有する記録ヘッドと読み出し用の磁気抵抗（以下、ＭＲ（Magneto Resistive ）と記す。）素子を有する再生ヘッドとを積層した構造の複合型薄膜磁気ヘッドが広く用いられている。ＭＲ素子としては、異方性磁気抵抗（以下、ＡＭＲ（Anisotropic Magneto Resistive ）と記す。）効果を有する膜を用いたＡＭＲ素子と、巨大磁気抵抗（以下、ＧＭＲ（Giant Magneto Resistive ）と記す。）効果を有する膜を用いたＧＭＲ素子とがあり、ＡＭＲ素子を用いた再生ヘッドはＡＭＲヘッドあるいは単にＭＲヘッドと呼ばれ、ＧＭＲ素子を用いた再生ヘッドはＧＭＲヘッドと呼ばれる。ＡＭＲヘッドは、面記録密度が１ギガビット／（インチ）^{2} を超える再生ヘッドとして利用され、ＧＭＲヘッドは、面記録密度が３ギガビット／（インチ）^{2} を超える再生ヘッドとして利用されている。

【０００３】一般的に、ＡＭＲ膜は、ＭＲ効果を示す磁性体を膜としたもので、単層構造になっている。これに対して、多くのＧＭＲ膜は、複数の膜を組み合わせた多層構造になっている。ＧＭＲ効果が発生するメカニズムにはいくつかの種類があり、そのメカニズムによってＧＭＲ膜の層構造が変わる。ＧＭＲ膜としては、超格子ＧＭＲ膜、スピンバルブ膜、グラニュラ膜等が提案されて

いるが、比較的構成が単純で、弱い磁界でも大きな抵抗変化を示し、量産を前提とするGMR膜としては、スピンバルブ膜が有力である。

【0004】再生ヘッドの性能を決定する要因としては、パターン幅、特に、MRハイトがある。MRハイトは、MR素子のエアベアリング面側の端部から反対側の端部までの長さ（高さ）をいう。このMRハイトは、本来、エアベアリング面の加工の際の研磨量によって制御される。なお、ここにいうエアベアリング面（ABS）は、薄膜磁気ヘッドの磁気記録媒体に対向する面であり、トラック面ともいう。

【0005】一方、再生ヘッドの性能向上に伴って、記録ヘッドの性能向上も求められている。記録ヘッドの性能のうち、記録密度を高めるには、磁気記録媒体におけるトラック密度を上げる必要がある。そのためには、記録ギャップ（write gap)を挟んでその上下に形成された下部磁極（ボトムポール）および上部磁極（トップポール）のエアベアリング面での幅を数ミクロンからサブミクロンオーダーまで狭くした狭トラック構造の記録ヘッドを実現する必要があり、そのため半導体加工技術が利用されている。

【0006】記録ヘッドの性能を決定するその他の要因としては、スロートハイト（ThroatHeight:TH）がある。スロートハイトは、エアベリング面から、薄膜コイルを電気的に分離する絶縁層のエッジまでの部分（磁極部分）の長さ（高さ）をいう。記録ヘッドの性能向上のためには、スロートハイトの縮小化が望まれている。このスロートハイトも、エアベアリング面の加工の際の研磨量によって制御される。

【0007】薄膜磁気ヘッドの性能の向上のためには、上述のような記録ヘッドと再生ヘッドをバランスよく形成することが重要である。

【0008】ここで、図11（a），（b）乃至図24（a），（b）を参照して、従来の薄膜磁気ヘッドの一例として複合型薄膜磁気ヘッドの製造方法の一例を説明する。

【0009】まず、図11に示したように、例えばアルティック（Al_2O_3・TiC）よりなる基板101上に、例えばアルミナ（酸化アルミニウム，Al_2O_3）よりなる絶縁層102を、約5～10μm程度の厚みで形成する。続いて、絶縁層102上に例えばパーマロイ（NiFe）からなる再生ヘッド用の下部シールド層103を形成する。

【0010】次に、図12に示したように、下部シールド層103上に、例えばアルミナを100～200nmの厚みで堆積し、シールドギャップ膜104を形成する。次に、シールドギャップ膜104上に、再生用のMR素子を構成するためのMR膜105を数十nmの厚みに形成し、高精度のフォトリソグラフィで所望の形状とする。続いて、このMR膜105に対するリード端子層106をリフトオフ法により形成する。次いで、シールドギャップ膜104、MR膜105およびリード端子層106上に、シールドギャップ膜107を形成し、MR膜105およびリード端子層106をシールドギャップ膜104，107内に埋設する。続いて、シールドギャップ膜107上に、再生ヘッドと記録ヘッドの双方に用いる磁気材料、例えばパーマロイ（NiFe）からなる膜厚3μmの上部シールド兼下部磁極（以下，下部磁極と記す。）108を形成する。

【0011】次に、図13に示したように、下部磁極108上に、絶縁層例えばアルミナ膜よりなる膜厚200nmの記録ギャップ層109を形成する。更に、この記録ギャップ層109をフォトリソグラフィによりパターニングし、上部磁極と下部磁極との接続用の開口109aを形成する。続いて、めっき法によりパーマロイ（NiFe）や窒化鉄（FeN）からなる磁気材料により磁極先端部（ポールチップ）110を形成すると共に、上部磁極と下部磁極との接続部パターン110aを形成する。この接続部パターン110aにより下部磁極108と後述の上部磁極層116とが接続され、後述のCMP（Chemical and Mechanical Polishing: 化学的機械研磨）工程後の開口（スルーホール）の形成が容易になる。

【0012】次に、図14に示したように、磁極先端部110をマスクとしてイオンミリングによって記録ギャップ層109と下部磁極108とを約0．3～0．5μm程度エッチングする。下部磁極108までエッチングしてトリム構造とすることにより、実効書き込みトラック幅の広がりが防止される（すなわち、データの書き込み時において、下部磁極における磁束の広がりが抑制される）。続いて、全面に、膜厚約3μmの例えばアルミナからなる絶縁層111を形成した後、全面をCMPにより平坦化する。

【0013】次に、図15に示したように、絶縁層111上に、例えばめっき法により、例えば銅（Cu）よりなる誘導型の記録ヘッド用の第1層目の薄膜コイル112を選択的に形成し、更に、絶縁層111および薄膜コイル112上に、フォトレジスト膜113を高精度のフォトリソグラフィで所定のパターンに形成する。続いて、フォトレジスト膜113の平坦化および薄膜コイル112間の絶縁化のために所定の温度で熱処理する。更に、同様に、フォトレジスト膜113上に、第2層目の薄膜コイル114およびフォトレジスト膜115を形成し、フォトレジスト膜115の平坦化および薄膜コイル114間の絶縁化のために所定の温度で熱処理する。

【0014】次に、図16に示したように、磁極先端部110、フォトレジスト膜113，115上に、記録ヘッド用の磁気材料、例えばパーマロイからなる上部ヨーク兼上部磁極層（以下、上部磁極層と記す。）116を形成する。この上部磁極層116は、薄膜コイル11

2，114よりも後方の位置において、下部磁極108と接触し、磁気的に連結される。続いて、上部磁極層116上に、例えばアルミナよりなるオーバーコート層117を形成する。最後に、スライダの機械加工を行って、記録ヘッドおよび再生ヘッドのトラック面（エアベアリング面）118を形成して、薄膜磁気ヘッドが完成する。

【0015】図16において、THはスロートハイトを表し、MR-HはMRハイトをそれぞれ表している。また、P2Wはトラック（磁極）幅を表している。

【0016】薄膜磁気ヘッドの性能を決定する要因として、スロートハイトTHやMRハイトMR-H等の他に、図16においてθで示したようなエイペックスアングル（Apex Angle）がある。このエイペックスアングルは、フォトレジスト膜113，115のトラック面側の側面の角部を結ぶ直線と上部磁極層116の上面とのなす角度をいう。

【0017】

【発明が解決しようとする課題】薄膜磁気ヘッドの性能を向上させるには、図16に示したようなスロートハイトTH、MRハイトMR-H、エイペックスアングルθおよびトラック幅P2Wを正確に形成することが重要である。

【0018】特に、近年は、高面密度記録を可能とするため、すなわち、狭トラック構造の記録ヘッドを形成するために、トラック幅P2Wには、1．0μm以下のサブミクロン寸法が要求されている。そのために、半導体加工技術を利用して上部磁極をサブミクロンに加工する技術が必要となる。また、狭トラック構造となるに伴って、磁極には、より高い飽和磁束密度を持った磁性材料の使用が望まれている。

【0019】ここで、問題となるのは、フォトレジスト膜（例えば、図16のフォトレジスト膜113，115）で覆われて山状に盛り上がったコイル部分（エイペックス部）の上に形成される上部磁極層（トップポール）116を微細に形成することが困難であることである。

【0020】上部磁極を形成する方法としては、例えば特開平7-262519号公報に示されるように、フレームめっき法が用いられる。フレームめっき法を用いて上部磁極を形成する場合は、まず、エイペックス部の上に全体的に、例えばパーマロイよりなる薄い電極膜を形成する。次に、その上にフォトレジストを塗布し、フォトリソグラフィによりパターニングして、めっきのためのフレーム（外枠）を形成する。そして、先に形成した電極膜をシード層として、めっき法によって上部磁極を形成する。

【0021】ところで、上述のエイペックス部では、例えば7～10μm以上の高低差がある。このエイペックス部上に形成されるフォトレジストの膜厚が最低3μm以上必要であるとすると、流動性のあるフォトレジストは低い方に集まることから、エイペックス部の下方では、例えば8～10μm以上の厚みのフォトレジスト膜が形成されることとなる。前述のように狭トラックを形成するためには、フォトレジスト膜によってサブミクロン幅のパターンを形成する必要がある。従って、8～10μm以上の厚みのあるフォトレジスト膜によって、サブミクロン幅の微細なパターンを形成する必要が生じるが、これは極めて困難であった。

【0022】しかも、フォトリソグラフィの露光時に、露光用の光が、例えばパーマロイよりなる電極膜で反射し、この反射光によってもフォトレジストが感光して、フォトレジストパターンのくずれ等が生じる。その結果、上部磁極の側壁が丸みを帯びた形状になる等、上部磁極を所望の形状に形成できなくなる。このように、従来は、トラックP2Wを正確に制御して、狭トラック構造とするための上部磁極を精度よく形成することが極めて困難であった。

【0023】このようなことから、上述の従来例の図13～図16の工程でも示したように、記録ヘッドの狭トラックの形成に有効な磁極先端部110で1．0μm以下のトラック幅を形成した後、この磁極先端部110とヨーク部を兼ねる上部磁極層116とを接続させる方法、すなわち、通常の上部磁極を、トラック幅を決定する磁極先端部110と、磁束を誘導するためのヨーク部となる上部磁極層116との2つに分割する方法が採用されている（特開昭62-245509，特開昭60-10409号公報参照）。このように上部磁極を2分割することにより、一方の磁極先端部110を記録ギャップ層109の平坦面上においてサブミクロン幅に微細に加工することが可能になる。

【0024】しかしながら、この薄膜磁気ヘッドにおいては、依然、以下のような問題があった。

【0025】（1）まず、従来の磁気ヘッドでは、磁極先端部110のトラック面118から遠い側の端部においてスロートハイトを決定している。しかし、この磁極先端部110の幅が狭くなると、フォトリソグラフィーにおいてパターンエッジが丸みを帯びて形成される。そのため、高精度な寸法を要求されるスロートハイトが不均一となり、トラック面の加工，研磨工程において、磁気抵抗効果素子のトラック幅との間のバランスに欠ける事態が発生していた。例えば、トラック幅として、0．5～0．6μm必要なときに、磁極先端部110のトラック面118から遠い側の端部がスロートハイト零の位置からトラック面側にずれ、大きく書き込みギャップが開き、記録データの書き込みができなくなるという問題がしばしば発生していた。

【0026】（2）次に、前述のように、従来の磁気ヘッドでは、2分割された上部磁極のうちの一方の磁極先端部110により記録ヘッドのトラック幅が規定される

ため、他方の上部磁極層１１６は磁極先端部１１０程には微細に加工する必要はないといえる。しかしながら、上部磁極層１１６は磁極先端部１１０の上部にフォトリソグラフィーの位置合わせにより位置が決定されるため、トラック面１１８（図１６）側から見た場合、双方が片側に大きく位置ずれすると、上部磁極層１１６側で書き込みを行う、所謂サイドライトが発生する。そのため実効トラック幅が広くなり、ハードディスクにおいて、本来のデータ記録領域以外の領域においても書き込みが行われる、という不具合が発生する。

【００２７】また、記録ヘッドのトラック幅が極微細、特に０．５μｍ以下になってくると、上部磁極層１１６においてもサブミクロン幅の加工精度が要求される。すなわち、トラック面１１８（図１６）側から見た場合、磁極先端部１１０と上部磁極層１１６との横方向の寸法差が大き過ぎると、上記と同様に、サイドライトが発生し、本来のデータ記録領域以外の領域においても書き込みが行われる、という不具合が発生する。

【００２８】このようなことから、磁極先端部１１０だけでなく、上部磁極層１１６もサブミクロン幅に加工する必要があるが、上部磁極層１１６の下のエイペックス部には、依然、前述のような大きな高低差があるため、上部磁極層１１６の微細加工が困難であった。

【００２９】（３）更に、従来の磁気ヘッドでは磁路長（Yoke Length）を短くすることが困難であるという問題があった。すなわち、コイルピッチが狭い程、磁路長の短いヘッドを実現することができ、特に高周波特性に優れた記録ヘッドを形成することができるが、コイルピッチを限りなく小さくしていった場合、スロートハイト零の位置から、コイルの外周端の距離が磁路長を妨げる大きな要因となっていた。磁路長は、一層のコイルよりは２層のコイルの方が短くできることから、多くの高周波用の記録ヘッドは２層コイルを採用している。しかしながら、従来の磁気ヘッドでは、１層目のコイルを形成した後、コイル間の絶縁膜を形成するために、フォトレジスト膜を約２μｍの厚さで形成している。そのため、１層目のコイルの外周端には丸みを帯びた小さなエイペックス部が形成される。次に、その上に２層目のコイルを形成するが、その際に、エイペックス部の傾斜部では、コイルのシード層のエッチングができず、コイルがショートするため、２層目のコイルを形成することができない。そのため、２層目のコイルは平坦部に形成する必要がある。コイルの厚みが２～３μｍで、更にコイル間絶縁膜の厚みを２μｍとすると、エイペックスの傾斜が４５～５５度の場合、コイルの外周端からスロートハイトの零の位置近傍まで４～５μｍの距離の２倍（上部磁極と下部磁極とのコンタクト部からコイル外周端までの距離も４～５μｍ必要）の８～１０μｍが必要であり、これが磁路長の縮小を妨げる要因となっていた。例えばライン／スペースが１．０μｍ／１．０μｍの１１巻コイルを２層で形成する場合、１層目を６巻、２層目を５巻とすると、磁路長のコイルを占める部分の長さは１１μｍである。ここで、上記コイル外周端のエイペックス部に８～１０μｍが必要なことから、これ以上磁路長の縮小は不可能で、これが高周波特性の改善を妨げていた。

【００３０】本発明はかかる問題点に鑑みてなされたもので、その第１の目的は、記録ヘッドにおけるスロートハイトの正確な制御が可能な薄膜磁気ヘッドおよびその製造方法を提供することにある。

【００３１】また、本発明の第２の目的は、スロートハイトの正確な制御に加え、磁極先端部だけでなく、上部磁極層のサブミクロン幅の極微細加工が可能であり、記録ヘッドの特性が改善された薄膜磁気ヘッドおよびその製造方法を提供することにある。

【００３２】更に、本発明の第３の目的は、スロートハイトの正確な制御に加え、記録ヘッドにおける磁路長の縮小が可能であり、高周波特性の改善された薄膜磁気ヘッドおよびその製造方法を提供することにある。

【００３３】

【課題を解決するための手段】本発明による薄膜磁気ヘッドは、磁気的に連結され、且つ記録媒体に対向する側の一部が記録ギャップ層を介して対向する第１の磁極および第２の磁極を含む少なくとも２つの磁性層と、磁束を発生させるための１層あるいは２層以上の薄膜コイルとを有する薄膜磁気ヘッドであって、第１の磁性層と、この第１の磁性層と分割して形成されると共に、記録ギャップ面との隣接面の反対側の面が、第１の磁性層の一部領域に磁気的に結合された第１の磁極と、無機系材料に形成されると共に、少なくとも第１の磁極の記録媒体に対向する側の反対面から第１の磁性層の一方の面に連続的に形成された絶縁層と、記録ギャップ層を介して第１の磁極に対向すると共に、記録媒体に対向する面から奥側に向けて第１の磁極よりも長く形成された第２の磁極と、この第２の磁極と分割して形成されると共に、第２の磁極の記録ギャップ面との隣接面の反対側の面の少なくとも一部において第２の磁極に磁気的に結合された第２の磁性層とを備えた構成を有している。

【００３４】本発明による薄膜磁気ヘッドでは、第１磁極が第１の磁性層と分割され、第１の磁性層に対して突状に形成されているため、無機系材料により形成された絶縁層が第１の磁極に隣接して形成される。従って、第１の磁極の記録媒体に対向する面からの奥行き方向への長さを、記録ヘッドのスロートハイトに等しくすることにより、スロートハイトが正確に規定される。また、記録ギャップ層を介して第１の磁極に対向する第２の磁極の長さを、第１の磁極よりも長くするようにしたので、第２の磁極と第２の磁性層との接触面積を十分確保でき、第２の磁極と第２の磁性層との磁気的結合が良好になる。

【００３５】更に、絶縁層が形成されている領域内に薄

膜コイルを埋め込むことにより、その分、コイルを含むエイペックス部の段差が従来構造に比べて低くなる。従って、第2の磁極をフォトリソグラフィー技術により形成する際に、エイペックス部の上部と下部とにおいてフォトレジスト膜の厚さの差が低減される。よって、第2の磁極のサブミクロン寸法の微細化が可能になる。

【0036】本発明による薄膜磁気ヘッドでは、上記構成に加えて、更に、以下の態様とすることができる。

【0037】すなわち、本発明による薄膜磁気ヘッドでは、第1の磁極の記録媒体に対向する面からの長さは、記録ヘッドのスロートハイトの長さに等しくすることが好ましい。

【0038】また、本発明による薄膜磁気ヘッドでは、第2の磁極は、第1の磁極よりも第2の磁極の膜厚相当分だけ長くすることが好ましい。

【0039】また、本発明による薄膜磁気ヘッドでは、少なくとも一層の薄膜コイルが、少なくともその膜厚方向の一部が前記絶縁層が形成されている領域内に位置するように形成する構成としてもよく、あるいは、絶縁層が、第1の磁極の記録媒体に対向する側の反対面から第1の磁性層の一方の面に沿って連続的に形成された第1の絶縁層と、少なくとも、薄膜コイルの巻線間に形成された第2の絶縁層とを含むように構成してもよい。更に、絶縁層の第1の磁性層との隣接面の反対面が、第1の磁極の記録ギャップ層との隣接面の反対面と実質的に同一面となるように形成するようにしてもよい。

【0040】また、本発明による薄膜磁気ヘッドでは、第1の磁極の記録媒体に対向する面に沿った幅が第2の磁極の幅よりも広く形成されている構成としてもよい。

【0041】更に、本発明による薄膜磁気ヘッドでは、第2の磁性層の記録媒体に対向する側と反対側の端部近傍において、第1の磁性層に隣接して形成された第1の接続部と、この第1の接続部に対向する位置において第2の磁性層に隣接して形成された第2の接続部とを備え、且つ、第1の接続部および第2の接続部それぞれの互いに対向する側の面積が異なる構成としてもよく、更に、第2の接続部の面積が第1の接続部のそれよりも広い構成としてもよい。

【0042】また、本発明による薄膜磁気ヘッドでは、第2の磁性層の記録媒体に対向する面側の端部が、記録媒体に対向する面から後退した位置に形成されている構成とすることが好ましい。

【0043】更に、本発明による薄膜磁気ヘッドでは、第1の絶縁層は、第1の磁極の記録媒体に対向する側の端面を除く両側面に沿って形成されている構成とし、また、薄膜コイルの膜厚方向の全部が、第1の絶縁層が形成されている領域内に形成されている構成としてもよい。更に第2の絶縁層が、第1の磁極の記録ギャップ層との隣接面と実質的に同一面となるように形成されている構成としてもよい。

【0044】また、本発明による薄膜磁気ヘッドでは、記録ギャップ層の一方の面が第2の絶縁層を覆うように形成され、更に、第3の絶縁層が、少なくとも、第2の磁極の記録媒体に対向する側の反対面から記録ギャップ層の他方の面にかけて連続的に形成されている構成としてもよい。更に、第3の絶縁層と第2の磁性層との間に、第1ないし第3の絶縁層とは異なる他の絶縁層に覆われて形成された少なくとも1層の薄膜コイルを備えた構成としてもよい。また、第3の絶縁層および他の絶縁層が、第2の磁極の記録ギャップ層との隣接面の反対面と実質的に同一面となるように形成されている構成としてもよい。

【0045】更に、本発明による薄膜磁気ヘッドでは、読み出し用の磁気抵抗効果素子を備えた構成としてもよい。

【0046】本発明による薄膜磁気ヘッドの製造方法は、磁気的に連結され、且つ記録媒体に対向する側の一部が記録ギャップ層を介して対向する第1の磁極および第2の磁極を含む少なくとも2つの磁性層と、磁束を発生させるための1層あるいは2層以上の薄膜コイルとを有する薄膜磁気ヘッドの製造方法であって、第1の磁性層を形成した後、第1の磁性層の上に、第1の磁性層の一部領域と磁気的に結合されるように第1の磁極を形成する工程と、少なくとも第1の磁極の記録媒体に対向する側の反対面から第1の磁性層の一方の面にかけて無機系材料からなる絶縁層を連続的に形成する工程と、少なくとも前記第1の磁極の上に記録ギャップ層を形成した後、前記第2の磁極を、記録媒体に対向する面から奥側に向けて前記第1の磁極よりも長く形成する工程と、第2の磁極に磁気的に結合させて第2の磁性層を形成する工程とを含むものである。

【0047】本発明による薄膜磁気ヘッドの製造方法では、第1の磁極が、第1の磁性層に対して突状に形成され、無機系材料により形成された絶縁層が第1の磁極に隣接して形成される。従って、第1の磁極の記録媒体に対向する面からの奥行き方向への長さを、記録ヘッドのスロートハイトの長さに等しくすることにより、スロートハイトが正確に規定される。また、記録ギャップ層を介して第1の磁極に対向する第2の磁極の長さが、第1の磁極よりも長く形成されるので、第2の磁極と第2の磁性層との接触面積が確保され、第2の磁極と第2の磁性層との磁気的結合が良好になる。

【0048】本発明による薄膜磁気ヘッドの製造方法では、上記構成に加えて、更に、以下の態様とすることができる。

【0049】すなわち、本発明による薄膜磁気ヘッドの製造方法では、第1の磁極を形成すると同時に、第2の磁性層の記録媒体に対向する側と反対側の端部近傍の位置において、第1の磁性層に隣接して第1の接続部を形成すると共に、第2の磁極を形成すると同時に、第2の

磁性層の記録媒体に対向する側と反対側の端部近傍の位置において、第２の磁性層に隣接して、第１の接続部と異なる面積の第２の接続部を形成するようにしてもよい。

【００５０】また、本発明による薄膜磁気ヘッドの製造方法では、少なくとも一層の薄膜コイルを、少なくともその膜厚方向の一部が絶縁層が形成されている領域内に位置するように形成する工程を含むようにしてもよく、あるいは、第１の磁極の記録媒体に対向する側の反対面から第１の磁性層の一方の面に沿って連続的に第１の絶縁層を形成する工程と、少なくとも薄膜コイルの巻線間に第２の絶縁層を形成する工程とを含むようにしてもよく、更に、第２の絶縁層の第１の磁性層との隣接面の反対面が、第１の磁極の前記記録ギャップ層との隣接面の反対面と実質的に同一面となるように平坦化する工程を含むようにしてもよい。

【００５１】更に、本発明による薄膜磁気ヘッドの製造方法では、第１の磁極の記録媒体に対向する面に沿った幅を第２の磁極よりも広く形成するようにしてもよい。

【００５２】また、本発明による薄膜磁気ヘッドの製造方法では、薄膜コイルの膜厚方向の全部を、第１の絶縁層が形成されている領域内に形成するようにしてもよい。

【００５３】更に、本発明による薄膜磁気ヘッドの製造方法では、第２の絶縁層を平坦化した後、第２の絶縁層上に記録ギャップ層を形成し、記録ギャップ層上に第２の磁極を形成した後、少なくとも記録ギャップ層上に第３の絶縁層を形成し、その後、記録ギャップ層上の第３の絶縁層の上に少なくとも１層の薄膜コイルを形成し、続いて薄膜コイルを第１乃至第３の絶縁層とは異なる他の絶縁層により覆うようにしてもよい。

【００５４】また、本発明による薄膜磁気ヘッドの製造方法では、他の絶縁層を無機系材料により形成した後、他の絶縁層を、その表面が第２の磁極の表面と同一面を形成するように平坦化し、その後、第２の磁極および平坦化された他の絶縁層上に第２の磁性層を形成するようにしてもよく、あるいは、他の絶縁層を有機系材料により選択的に形成した後、第２の磁極および他の絶縁層上に第２の磁性層を形成するようにしてもよい。

【００５５】更に、本発明による薄膜磁気ヘッドの製造方法では、読み出し用の磁気抵抗効果素子を形成する工程を含むようにしてもよい。

【００５６】

【発明の実施の形態】以下、本発明の実施の形態について図面を参照して詳細に説明する。

【００５７】〔第１の実施の形態〕図１（ａ），（ｂ）ないし図７（ａ），（ｂ）は、それぞれ、本発明の第１の実施の形態に係る薄膜磁気ヘッドとしての複合型薄膜磁気ヘッドの製造工程を表すものである。なお、図１ないし図７において、（ａ）はトラック面（ＡＢＳ）に垂直な断面を示し、（ｂ）は磁極部分のトラック面に平行な断面をそれぞれ示している。

【００５８】まず、図７（ａ），（ｂ）を参照して本実施の形態に係る複合型薄膜磁気ヘッドの構成について説明する。この磁気ヘッドは、再生用の磁気抵抗効果読み出しヘッド部（以下，再生ヘッド部という）１Ａと、記録用のインダクティブ記録ヘッド部（以下，記録ヘッド部という）１Ｂとを有している。

【００５９】再生ヘッド部１Ａは、例えばアルティック（Al_2O_3・ＴｉＣ）からなる基板１１上に、例えばアルミナ（酸化アルミニウム，Al_2O_3）により形成された絶縁層１２、例えば珪化鉄アルミニウム（ＦｅＡｌＳｉ）により形成された下部シールド層１３、例えばアルミナにより形成されたシールドギャップ層１４を順次介して磁気抵抗効果膜（以下，ＭＲ膜という）１５のパターンを形成したものである。また、シールドギャップ層１４上には、例えばタンタル（Ｔａ）やタングステン（Ｗ）等のＭＲ膜に拡散しない材料により形成されたリード端子層１５ａも形成されており、このリード端子層１５ａがＭＲ膜１５に電気的に接続されている。ＭＲ膜１５は、例えばパーマロイ（ＮｉＦｅ合金）やニッケル（Ｎｉ）－コバルト（Ｃｏ）合金など磁気抵抗効果を有する各種材料により形成されている。ＭＲ膜１５およびリード端子層１５ａの上には例えばアルミナよりなるシールドギャップ層１７が積層されている。つまり、ＭＲ膜１５とリード端子層１５ａとはシールドギャップ層１４，１７間に埋設されている。なお、ＭＲ膜１５は、特に限定するものではなく、ＡＭＲ膜やＧＭＲ膜あるいは他の磁気抵抗効果膜などでもよい。

【００６０】記録ヘッド部１Ｂは、この再生ヘッド部１Ａ上に、ＭＲ膜１５に対する上部シールド層を兼ねる下部磁極および記録ギャップ層２２を介して上部磁極を形成したものである。

【００６１】本実施の形態では、下部磁極は、シールドギャップ層１７上に形成された下部磁極層（下部ポール）１８と、トラック面側において下部磁極層１８上に形成された下部磁極先端部（下部ポールチップ）１９ａとに２分割して形成されている。同様に、上部磁極も２分割されており、トラック面側において、下部磁極先端部１９ａ上に記録ギャップ層２２を間にして形成された上部磁極先端部（上部ポールチップ）２３ａと、この上部磁極先端部２３ａに接触すると共に、後述のコイルを含むエイペックス部の上面に沿って形成された、ヨーク部を兼ねる上部磁極層（上部ポール）２５とにより構成されている。上部磁極層２５は、エイペックス部のトラック面と反対側の位置（図７（ａ）において右側）において、上部接続部２３ｂおよび下部接続部１９ｂを介して下部磁極層１８と磁気的に結合されている。

【００６２】上部接続部２３ｂの幅は下部接続部１９ｂの幅と異なる、すなわち面積が異なっており、本実施の

形態では、上部接続部２３ｂの面積が下部接続部１９ｂの面積よりも大きくなっている。また、下部接続部１９ｂは上部接続部２３ｂの中央位置に接触しており、これにより上部磁極層２５から下部磁極層１８への磁束の流れが円滑になるようになっている。

【００６３】以上の下部磁極層１８、下部磁極先端部１９ａ、下部接続部１９ｂ、上部磁極先端部２３ａ、上部接続部２３ｂおよび上部磁極層２５は、それぞれ、例えば高飽和磁束密度材料（Ｈｉ－Ｂｓ材）、例えばＮｉＦｅ（Ｎｉ：５０重量％，Ｆｅ：５０重量％），ＮｉＦｅ（Ｎｉ：８０重量％，Ｆｅ：２０重量％），ＦｅＮ，ＦｅＺｒＮＰ，ＣｏＦｅＮなどにより形成されている。

【００６４】この記録ヘッド部１Ｂでは、上部磁極先端部２３ａに対向する下部磁極磁極先端部１９ａは、その表面部分を一部突状に加工したトリム（Trim）構造となっている。これにより、実効書き込みトラック幅の広がり、すなわち、データの書き込み時において、下部磁極における磁束の広がりが抑制されるようになっている。

【００６５】なお、本実施の形態においては、下部磁極層１８が本発明の第１の磁性層、下部磁極先端部１９ａが本発明の第１の磁極にそれぞれ対応し、また、上部磁極先端部２３ａが本発明の第２の磁極、上部磁極層２５が本発明の第２の磁性層にそれぞれ対応している。

【００６６】本実施の形態では、１層目の薄膜コイル２１は、下部磁極層１８上の下部磁極先端部１９ａと下部接続部１９ｂとの間の凹部領域に形成されている。すなわち、凹部領域の内壁面（底面および側壁面）には絶縁層２０ａが形成され、この絶縁層２０ａ上に薄膜コイル２１が形成されている。薄膜コイル２１のコイル間は絶縁層２０ｂにより埋め込まれており、この絶縁層２０ｂの表面と下部磁極先端部１９ａの表面とが同一面を構成するように平坦化されている。よって、この薄膜コイル２１の分だけ、後述の薄膜コイル２４を含むエイペックス部の段差が低くなっている。なお、絶縁層２０ａが本発明の第１の絶縁層、絶縁層２０ｂが本発明の第２の絶縁層にそれぞれ対応している。

【００６７】平坦化された絶縁層２０ｂおよび薄膜コイル２１上には記録ギャップ層２２が延在している。この記録ギャップ層２２上の上部磁極先端部２３ａと上部接続部２３ｂとの間の凹部領域内には絶縁層２０ｃが形成されている。この絶縁層２０ｃ上に２層目の薄膜コイル２４が形成されている。この薄膜コイル２４は例えばアルミナからなる絶縁層２０ｄにより覆われている。この絶縁層２０ｄが本発明の他の絶縁層に対応している。

【００６８】絶縁層２０ｄ上にはヨーク部を兼ねる上部磁極層２５が形成されている。上部磁極層２５はオーバーコート層２６により覆われている。なお、図示しないが、薄膜コイル２１，２４は絶縁層２０ｂと絶縁層２０ｄとの境界面において電気的に接続されている。

【００６９】この磁気ヘッドでは、再生ヘッド部１Ａにおいて、ＭＲ膜１５の磁気抵抗効果を利用して図示しない磁気ディスクから情報の読み出しが行われると共に、記録ヘッド部１Ｂにおいて、薄膜コイル２１，２４による、上部磁極先端部２３ａと下部磁極先端部１９ａとの間の磁束の変化を利用して磁気ディスクに対して情報が書き込まれる。

【００７０】次に、上記複合型薄膜磁気ヘッドの製造方法について説明する。

【００７１】本実施の形態に係る製造方法では、まず、図１に示したように、例えばアルティック（Al_2O_3・ＴｉＣ）からなる基板１１上に、例えばスパッタ法により例えばアルミナ（Al_2O_3）よりなる絶縁層１２を、約３～５μｍ程度の厚みで形成する。次に、絶縁層１２上に、フォトレジスト膜をマスクとして、めっき法にて、パーマロイ（ＮｉＦｅ）を約３μｍの厚みで選択的に形成して、再生ヘッド用の下部シールド層１３を形成する。続いて、例えばスパッタまたはＣＶＤ（Chemical Vapor Deposition）法により約４～６μｍの厚さのアルミナ膜（図示せず）を形成し、ＣＭＰによって平坦化する。

【００７２】次に、図２に示したように、下部シールド層１３上に、例えばアルミナを１００～２００ｎｍの厚みでスパッタ法により堆積し、シールドギャップ層１４を形成する。続いて、シールドギャップ層１４上に、再生用のＭＲ素子等を構成するためのＭＲ膜１５を、数十ｎｍの厚みに形成し、高精度のフォトリソグラフィで所望の形状とする。続いて、このＭＲ膜１５に対するリード端子層１５ａをリフトオフ法により形成する。次いで、シールドギャップ層１４、ＭＲ膜１５およびリード端子層１５ａ上に、シールドギャップ層１７を形成し、ＭＲ膜１５およびリード端子層１５ａをシールドギャップ層１４，１７内に埋設する。

【００７３】続いて、シールドギャップ膜１７上に、例えばパーマロイ（ＮｉＦｅ）よりなる上部シールドを兼ねた下部磁極層（下部ポール）１８を、約１．０～１．５μｍの厚みで形成する。

【００７４】次に、図３に示したように、下部磁極層１８上に、下部磁極先端部（下部ポールチップ）１９ａおよび下部接続部１９ｂを約２．０～２．５μｍの厚みで形成する。ここで、下部磁極先端部１９ａは、そのトラック側の先端部がＭＲ（ＧＭＲ）ハイト零の位置の近辺になるように成形し、同時に、トラック面の反対側がスロートハイト零の位置となるようにする。なお、この下部磁極先端部１９ａおよび下部接続部１９ｂは、前述のようにＮｉＦｅ等のめっき膜により形成してもよく、ＦｅＮ，ＦｅＺｒＮＰ，ＣｏＦｅＮなどのスパッタ膜により形成してもよい。

【００７５】続いて、全面に、例えばスパッタ法またはＣＶＤ法により絶縁材料、例えばアルミナよりなる膜厚０．３～０．６μｍの絶縁層２０ａを形成する。

【００７６】次に、図４に示したように、下部磁極先端部１９ａと下部接続部１９ｂとの間に形成された凹部領域に、例えば電解めっき法により、例えば銅（Ｃｕ）よりなる誘導型の記録ヘッド用の１層目の薄膜コイル２１を１．５～２．５μｍの厚みで形成する。

【００７７】次に、図５に示したように、全面に、スパッタ法により絶縁材料、例えばアルミナよりなる膜厚３．０～４．０μｍの絶縁層２０ｂを形成した後、例えばＣＭＰ法により表面を平坦化し、下部磁極先端部１９ａの表面を露出させる。このとき、本実施の形態では、薄膜コイル２１の表面も同時に露出するが、薄膜コイル２１の後述する２層目の薄膜コイル２４との接続部以外の表面部分は露出しなくてもよい。

【００７８】次に、図６に示したように、スパッタ法により絶縁材料、例えばアルミナよりなる膜厚０．２～０．３μｍの記録ギャップ層２２を形成する。記録ギャップ層２２は、アルミナの他、窒化アルミニウム（ＡｌＮ）、シリコン酸化物系、シリコン窒化物系の材料などにより形成するようにしてもよい。続いて、この記録ギャップ層２２をフォトリソグラフィーによりパターニングし、上部磁極と下部磁極との接続用の開口２２ａを形成する。

【００７９】続いて、記録ギャップ層２２上に記録ヘッドのトラック幅を決定するための上部磁極先端部（ポールチップ）２３ａをフォトリソグラフィーにより形成する。すなわち、記録ギャップ層２２上に、例えばスパッタ法により高飽和磁束密度材料（Ｈｉ－Ｂｓ材）、例えばＮｉＦｅ（Ｎｉ：５０重量％，Ｆｅ：５０重量％），ＮｉＦｅ（Ｎｉ：８０重量％，Ｆｅ：２０重量％），ＦｅＮ，ＦｅＺｒＮＰ，ＣｏＦｅＮなどからなる、膜厚２．５～３．５μｍの磁極層を形成する。続いて、この磁極層を、フォトレジストマスクを用いた例えばＡｒ（アルゴン）のイオンミリングによって選択的に除去し、上部磁極先端部２３ａを形成すると共に、上部磁極と下部磁極とを磁気的に接続させるための上部接続部２３ｂを形成する。上部磁極先端部２３ａおよび上部接続部２３ｂはフォトレジストマスクの代わりにアルミナ等の無機系絶縁層によるマスクを用いてエッチングするようにしてもよく、また、このようなフォトリソグラフィーによらず、その他、めっき法、スパッタ法などによって形成するようにしてもよい。

【００８０】ここで、本実施の形態では、上部磁極先端部２３ａを、トラック面から奥側に下部磁極先端部１９ａよりも長く形成すると共に、上部接続部２３ｂを下部接続部１９ｂよりも幅広く形成し、且つ、上部接続部２３ｂの中央位置に下部接続部１９ｂが接触されるようにする。

【００８１】続いて、上部磁極先端部２３ａをマスクとして、その周辺の記録ギャップ層２２および下部磁極先端部１９ａを自己整合的にエッチングする。すなわち、上部磁極先端部２３ａをマスクとした塩素系ガス（Cl_2，CF_4，BCl_2，SF_6 等）によるＲＩＥ（Reactive Ion Etching）により、記録ギャップ層２２を選択的に除去した後、露出した下部磁極先端部１９ａを、再び、例えばＡｒのイオンミリングによって約０．３～０．６μｍ程度エッチングして、トリム構造の記録トラックを形成する。

【００８２】続いて、全面に、例えばスパッタ法またはＣＶＤ法により、膜厚約０．３～０．６μｍの例えばアルミナからなる絶縁層２０ｃを形成する。続いて、この絶縁層２０ｃ上に、例えば電解めっき法により、例えば銅（Ｃｕ）よりなる誘導型の記録ヘッド用の２層目の薄膜コイル２４を１．５～２．５μｍの厚みで形成する。

【００８３】続いて、全面に、例えばスパッタ法またはＣＶＤ法により、膜厚約３～４μｍの例えばアルミナからなる絶縁層２０ｄを形成する。なお、この絶縁層２０ｄや絶縁層２０ｃは、アルミナに限らず、二酸化珪素（SiO_2）や、窒化珪素（ＳｉＮ）等の他の絶縁材料により形成してもよい。続いて、例えばＣＭＰ法により、上部磁極先端部２３ａおよび上部接続部２３ｂの表面が露出するように絶縁層２０ｄおよび絶縁層２０ｃをエッチングし、絶縁層２０ｃ，２０ｄの表面と上部磁極先端部２３ａおよび上部接続部２３ｂの各表面とが同一面を構成するように平坦化する。

【００８４】次に、図７に示したように、例えば上部磁極先端部２３ａと同じ材料を用いて、例えば電解めっき法やスパッタ法などの方法により、上部磁極層２５を約３～４μｍの厚みに形成する。この上部磁極層２５は、トラック面側から見て、薄膜コイル２１，２４よりも後方の位置において、上部接続部２３ｂを介して、下部接続部１９ｂと接触し、下部磁性層１８と磁気的に連結される。最後に、上部磁極層２５上に、例えばスパッタ法によりアルミナよりなる膜厚約３０μｍのオーバーコート層２６を形成する。その後、スライダの機械加工を行い、記録ヘッドおよび再生ヘッドのトラック面（ＡＢＳ）を形成することにより、薄膜磁気ヘッドが完成する。

【００８５】なお、図８は、本実施の形態に係る薄膜磁気ヘッドの平面図である。なお、この図は、スライダの機械加工を行う前の状態を表している。これらの図において、ＴＨはスロートハイトを表しており、このスロートハイトＴＨは、絶縁層２０ａの磁極部分側の端縁、すなわち下部磁極先端部１９ａのトラック面と反対側の端縁によって規定される。この図では、スロートハイトＴＨはＧＭＲハイトと一致しているため、ＴＨ＝ＧＭＲハイトとなる。なお、薄膜コイル２１にはリード端子２１ａの一方の端部が接続されている。このリード端子２１ａの他方の端部は、電極引き出し用パッド部（図示せず）に接続されている。また、一方の端部がＭＲ素子１５に接続されたリード端子層１５ａの他方の端部も同じ

く電極引き出し用パッド部（図示せず）に接続されている。

【００８６】以上の本実施の形態では、次のような効果を得ることができる。

【００８７】（１）まず、本実施の形態では、下部磁極を、下部磁極先端部１９ａと下部磁極層１８とに２分割し、下部磁極先端部１９ａを、下部磁極層１８の平坦面上に形成するようにしたので、無機材料からなる絶縁層２０ａ，２０ｂを下部磁極先端部１９ａと下部接続部１９ｂとの間の凹部内に埋め込むことができる。従って、絶縁層２０ａの下部磁極先端部１９ａ側の端縁（すなわち下部磁極先端部１９ａのトラック面と反対側の端縁）によってスロートハイトが規定される。よって、従来のフォトレジスト膜のように、端縁の位置変動（パターンシフト）およびプロファイル悪化が生じることがなく、スロートハイトの正確な制御が可能になる。更に、ＭＲハイトの正確な制御や、エイペックスアングルの正確な制御も可能となる。

【００８８】（２）また、本実施の形態では、上部磁極先端部２３ａを、下部磁極先端部１９ａよりも長く形成するようにしたので、上部磁極先端部２３ａを下部磁極先端部１９ａと同じ長さとした場合に比べて、上部磁極先端部２３ａと上部磁極層２５との接触面積を大きくすることができ、その部分での磁気的結合が良好となる。特に、本実施の形態のように、上部磁極層２５をトラック面から後退した位置に設ける構造（リセス構造）とした場合には、このような構成が有効である。すなわち、上部磁極層２５が、スロートハイトＴＨ＝零の位置（下部磁極先端部１９ａのトラック面と反対側の端縁）よりトラック面側に近い位置、例えばＴＨ＝０．５μｍの近傍位置に存在すると、上部磁極層２５によって隣接するトラックに情報を書き込むサイドライト不良が発生する。理想的には、上部磁極層２５は、ＴＨが零の位置より、トラック面から遠い位置に形成することが望ましい。一方、本実施の形態では、ＴＨを決めるための下部磁極先端部１９ａを、上部磁極先端部２３ａを介して上部磁極層２５と磁気的に結合させるものであり、上部磁極先端部２３ａと上部磁極層２５とは、ＴＨが零の位置より、トラック面と反対方向においてしっかり接続させる必要がある。このようなことから、上部磁極先端部２３ａは下部磁極先端部１９ａよりも長く形成することが望ましい。

【００８９】（３）また、本実施の形態では、図８に示したように、各パターンを真上から見た場合、下部磁極先端部１９ａの幅を上部磁極先端部２３ａの幅よりも広くしているために、上部磁極先端部２３ａがハーフミクロン幅の狭トラックであっても、下部磁極先端部１９ａの近傍において磁束が飽和することがない。

【００９０】（４）ところで、上部磁極先端部２３ａおよび下部磁極先端部１９ａが微細化され、その幅が狭くなるに伴って、上部磁極と下部磁極とのコンタクト部、すなわち、下部接続部１９ｂおよび上部接続部２３ｂの幅も狭くなる。このように下部接続部１９ｂおよび上部接続部２３ｂの幅が微細化された場合、下部接続部１９ｂの側壁の下部磁性層１８に対する角度、あるいは上部接続部２３ｂの側壁の上部磁性層２５に対する角度がそれぞれ垂直である場合には、その部分において磁束が飽和してしまう虞れがある。これに対して、本実施の形態では、上部接続部２３ｂの面積が下部接続部１９ｂよりも大きくなっており、しかも、下部接続部１９ｂが上部接続部２３ｂの中央部に対向しているため、断面で見た場合、コンタクト部全体は、上下のコイル間の傾斜面に沿ったスロープを有する形状、すなわち、コンタクト部全体があたかも漏斗のような形状となる。従って、上部磁極から下部磁極への磁束の流れが円滑となり、両磁極の磁気的結合が良好となる。なお、上部接続部２３ｂおよび下部接続部１９ｂそれぞれにもテーパを設ける構成としてもよく、このような構成により、上部磁極から下部磁極への磁束の流れがより円滑となる。また、逆に、下部接続部１９ｂ側の面積が上部接続部２３ｂの面積よりも広くなるような構成としてもよい。

【００９１】（５）更に、本実施の形態では、薄膜コイル２１と上部シールドを兼ねた下部磁極層１８との間には無機系の絶縁膜２０ａ，２０ｂ、また、薄膜コイル２１，２４間には記録ギャップ膜２２および絶縁層２０ｃが設けられていため、各絶縁層の厚さを調整することにより、薄膜コイル２１，２４、上部シールドとの間にそれぞれ大きな絶縁耐圧を得ることができ、絶縁性を保持することができると共に薄膜コイル２１，２４からの磁束の漏れを低減できる。

【００９２】（６）また、本実施の形態では、上部磁極を、上部磁極先端部２３ａと上部磁極層２５とに２分割し、上部磁極先端部２３ａを、下部磁極先端部１９ａ上の平坦面に形成するようにしたので、記録トラック幅を規制する上部磁極先端部２３ａをサブミクロン寸法に精度良く形成することができる。加えて、本実施の形態では、１層目の薄膜コイル２１が絶縁層２０ｂによって下部磁極先端部１９ａに隣接した凹部領域内に埋め込まれると共に、絶縁層２０ｂの表面が下部磁極先端部１９ａの表面と同一面を形成する程度に平坦化されている。すなわち、２層目の薄膜コイル２４を含むエイペックス部の段差が、１層目の薄膜コイル２１の分だけ、従来構造に比べて低くなる。従って、上部磁極先端部２３ａに部分的に接触する上部磁極層２５をフォトリソグラフィーにより形成する際に、エイペックス部の上部と下部においてフォトレジスト膜の厚さの差が低減され、その結果、上部磁極層２５のサブミクロン寸法の微細化を図ることが可能になる。よって、本実施の形態により得られる薄膜磁気ヘッドでは、記録ヘッドによる高面密度記録が可能となり、コイルを２層，３層と積層して記録ヘッ

ドの性能を更に向上させることができる。なお、上部磁極先端部２３ａおよび上部磁極層２５のフォトリソグラフィーの際に、フォトレジストの代わりに無機系絶縁層をマスクとすることにより、上部磁極先端部２３ａおよび上部磁極層２５の微細化を、より高精度に実現することが可能になる。また、上部磁極先端部２３ａおよび上部磁極層２５をフォトリソグラフィー以外のスパッタ等により形成する場合においても、同様に、エイペックス部の段差の影響が低減されるため、上部磁極先端部２３ａおよび上部磁極層２５の微細化を図ることができる。

【００９３】（７）更に、本実施の形態では、従来例のようにフォトレジストパターンの傾斜部が存在しないため、第１および第２層目の薄膜コイル２１，２４を共に平坦部に形成することができ、傾斜部によるコイル外周部端とスロートハイト零の位置までの距離が磁路長縮小の妨げとはならない。従って、本実施の形態では、磁路長を短くすることができ、記録ヘッドの高周波特性を著しく向上させることができる。ちなみに、本実施の形態では、フォトリソグラフィーの位置合わせ誤差の０．１μｍ～．０．２μｍで設計できるため、従来例の５０％以下に磁路長を縮小することが可能になる。

【００９４】（８）また、本実施の形態では、上部磁極先端部２３ａ，上部磁極層２５等の磁性層は高飽和磁束密度（Ｈｉ－Ｂｓ）材により形成されているので、トラック幅が狭くなっても、薄膜コイル２１，２４に発生した磁気が途中で飽和することなく、有効に上部磁極先端部２３ａおよび下部磁極先端部１９ａに到達し、これによって磁気損失のない記録ヘッドを実現できる。

【００９５】（９）更に、本実施の形態では、トラック幅を決定する上部磁極先端部２３ａの上に形成された上部磁極層２５が、トラック面に露出していないため、上部磁極層２５によるサイドライトが発生することはない。

【００９６】（１０）また、本実施の形態では、トラック幅を決定する上部磁極先端部２３ａが、上部磁極層２５よりも薄いため、上部磁極層２５から多くの磁束が流れてきても、上部磁極層２５と記録ギャップ層２２との間の距離が短いため、この部分において磁束が飽和することがなくなり、オーバーライト（重ね書き）特性や非線形トランジション（ＮＬＴＳ）特性が向上する。

【００９７】以下、本発明の他の実施の形態について説明する。なお、以下の説明では、第１の実施の形態と同一の構成部分については同一の符号を付してその説明は省略し、異なる部分についてのみ説明する。

【００９８】〔第２の実施の形態〕図９（ａ），（ｂ）は、本発明の第２の実施の形態に係る複合型薄膜磁気ヘッドの構成を表すものである。第１の実施の形態では、第２層目の薄膜コイル２４を、上部磁極先端部２３ａの表面より下、すなわち、平坦化された絶縁層２０ｄ内に完全に埋め込む構造としたが、上部磁極先端部２３ａが薄い場合には、ＣＭＰ等の平坦化工程において、薄膜コイル２４の表面が露出することがある。本実施の形態では、このような場合に、薄膜コイル２４と上部磁極層２５との間の絶縁性を確保するために、薄膜コイル２４と上部磁極層２５との間に、例えば膜厚１．０μｍのフォトレジストによる絶縁層３０を選択的に形成するようにしたものである。その他の構成および作用効果は第１の実施の形態と同様であるのでその説明は省略する。

【００９９】〔第３の実施の形態〕本実施の形態は、図１０（ａ），（ｂ），（ｃ）に示したように、２層目の薄膜コイル２４を形成する工程までは、第１の実施の形態と同様であるが、その後、フォトレジスト膜３１により薄膜コイル２４を覆い、続いて、このフォトレジスト膜３１上に上部磁極層２５を、その先端部がトラック面に露出しないように形成したものである。なお、同図（ｃ）は同図（ａ），（ｂ）のうちの下部磁極先端部１９ａ，下部接続部１９ｂ，上部磁極先端部２３ａ、下部接続部２３ｂおよび上部磁極層２５を取り出して示す平面図である。

【０１００】本実施の形態では、第１の実施の形態とは異なり、２層目の薄膜コイル２４を形成した後にＣＭＰによる平坦化は行う必要がない。従って、その分、第１の実施の形態に比べて製造コストは低減される。なお、２層目の薄膜コイル２４は5巻とし、６巻の１層目の薄膜コイル２１の平坦化された部分に形成されるため、薄膜コイル２４の外周端からスロートハイト零の位置までの距離が磁路長の妨げとなることはない。その他の構成および作用効果は第１の実施の形態と同様であるので、その説明は省略する。

【０１０１】以上実施の形態を挙げて本発明を説明したが、本発明は上記実施の形態に限定されるものではなく種々変形可能である。例えば、上記実施の形態において、上部磁極先端部２３ａおよび上部磁極層２５等は、ＮｉＦｅ（Ｎｉ：５０重量％，Ｆｅ：５０重量％），ＮｉＦｅ（Ｎｉ：８０重量％，Ｆｅ：２０重量％）の他、ＦｅＮ，ＦｅＣｏＺｒ等の高飽和磁束密度材を用いる例について説明したが、これらの材料を２種類以上積層した構造としてもよい。

【０１０２】また、第１ないし第５の実施の形態では、下部磁極先端部１９ａに隣接して形成された凹部内に埋め込まれる薄膜コイルを１層としたが、２層以上のコイルを埋め込む積層構造としてもよい。

【０１０３】更に、上記実施の形態では、下部磁極先端部１９ａを、その側壁が下部磁極層１８に対して垂直な形状としたが、コイルの厚さに応じて例えばθ＝５０～７０度程度の傾斜面（テーパ）を設けるようにしてもよい。このような構成とすることにより、下部磁極層１８と下部磁極先端部１９ａとの接続部における磁束の飽和を抑制し、磁束の流れが滑らかになる。

【０１０４】また、上記実施の形態では、上部磁極層２

5をトラック面から後退した位置に形成する構造（リセス構造）について説明したが、上部磁極層25の厚さを上部磁極先端部23aよりも相対的に厚くすることにより、上部磁極層25を上部磁極先端部23aと共にトラック面に露出させる構造としてもよい。これによりリセス構造としなくても、上部磁極層25によりサイドライトが発生する不具合を解消することができる。

【0105】更に、上記実施の形態では、下部磁極先端部19aに隣接した凹部領域において、絶縁層により第1層目の薄膜コイルを埋め込む構造としたが、薄膜コイルを埋め込むことなく、凹部領域全体を例えばアルミナからなる無機系の絶縁層とするようにしてもよい。なお、上記実施の形態では、下部磁極を第1の磁性層に、上部磁極を第2の磁性層にそれぞれ対応させた構成を示したが、この対応を逆にした構成も可能である。つまり、下部磁極を第2の磁性層に、上部磁極を第1の磁性層にそれぞれ対応させた構成としてもよい。

【0106】また、上記各実施の形態では、複合型薄膜磁気ヘッドの製造方法について説明したが、本発明は、書き込み用の誘導型磁気変換素子を有する記録専用の薄膜磁気ヘッドや記録・再生兼用の薄膜磁気ヘッドの製造にも適用することができる。また、本発明は、書き込み用の素子と再生用の素子の積層の順序を入れ換えた構造の薄膜磁気ヘッドの製造にも適用することも可能である。

【0107】

【発明の効果】以上説明したように本発明に係る薄膜磁気ヘッド、または本発明に係る薄膜磁気ヘッドの製造方法によれば、第1の磁極を、第1の磁極層と分割すると共に第1の磁極層上に突状に形成するようにしたので、無機材料からなる絶縁層を第1の磁極に隣接した凹部内に埋め込むことができる。よって、第1の磁極のトラック面と反対側の端縁によってスロートハイトが規定され、従来のフォトレジスト膜のように端縁の位置変動およびプロファイル悪化が生じることがなく、スロートハイトの正確な制御が可能になるという効果を奏する。また、第1の磁極に対向する第2の磁極も、第2の磁極層と分割し、且つ、この第2の磁極を第1の磁極よりもトラック面から奥側へ長く形成するようにしたので、第2の磁極をサブミクロン寸法に微細化できると共に、第2の磁極と第2の磁性層との接触面積が増し、磁束の流れが円滑になり、上記スローハイトの正確な制御と相まって、高精度の薄膜磁気ヘッドを実現することができる。

【0108】また、第1の磁極に隣接した凹部内に薄膜コイルを埋め込むようにすれば、その分、エイペックス部の段差を従来構造に比べて低くすることができ、その後の工程において、第2の磁性層をフォトリソグラフィーにより形成する際に、エイペックス部の上部と下部においてフォトレジスト膜の厚さの差が低減され、その結果、第2の磁性層のサブミクロン寸法の微細化を図ることが可能になる。よって、記録ヘッドによる高面密度記録が可能となり、コイルを2層，3層と積層することにより、記録ヘッドの性能を更に向上させることが可能になる。

【図面の簡単な説明】

【図1】本発明の第1の実施の形態に係る薄膜磁気ヘッドの製造工程を説明するための断面図である。

【図2】図1に続く工程を説明するための断面図である。

【図3】図2に続く工程を説明するための断面図である。

【図4】図3に続く工程を説明するための断面図である。

【図5】図4に続く工程を説明するための断面図である。

【図6】図5に続く工程を説明するための断面図である。

【図7】図6に続く工程を説明するための断面図である。

【図8】本発明の第1の実施の形態によって製造される薄膜磁気ヘッドの平面図である。

【図9】本発明の第2の実施の形態に係る薄膜磁気ヘッドの構成を説明するための断面図である。

【図10】本発明の第3の実施の形態に係る薄膜磁気ヘッドの構成を説明するための断面図および平面図である。

【図11】従来の薄膜磁気ヘッドの製造工程を説明するための断面図である。

【図12】図11に続く工程を説明するための断面図である。

【図13】図12に続く工程を説明するための断面図である。

【図14】図13に続く工程を説明するための断面図である。

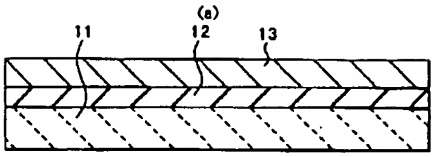
【図15】図14に続く工程を説明するための断面図である。

【図16】図15に続く工程を説明するための断面図である。

【符号の説明】

11…基板、18…上部シールド兼下部磁極（下部磁極層）（第1の磁性層）、19a…下部磁極先端部（第1の磁極）、22…記録ギャップ層、23a…上部磁極先端部（第2の磁極）、20a…絶縁層（第1の絶縁層）、20b…絶縁層（第2の絶縁層）、20c…絶縁層（第3の絶縁層）、20d…絶縁層（他の絶縁層）、21，24…薄膜コイル、25…上部磁極層（第2の磁性層）

【図1】



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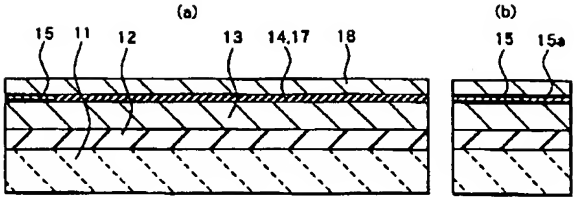

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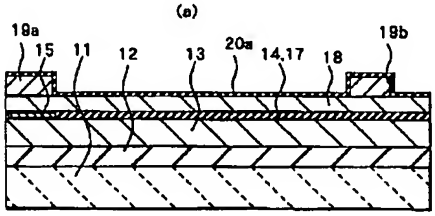

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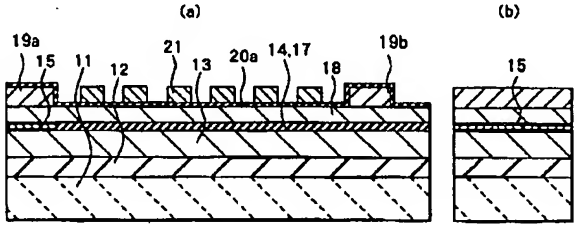

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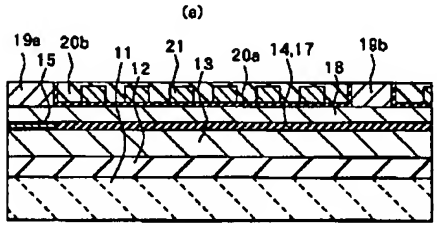

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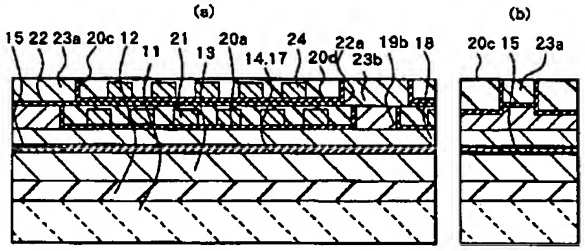

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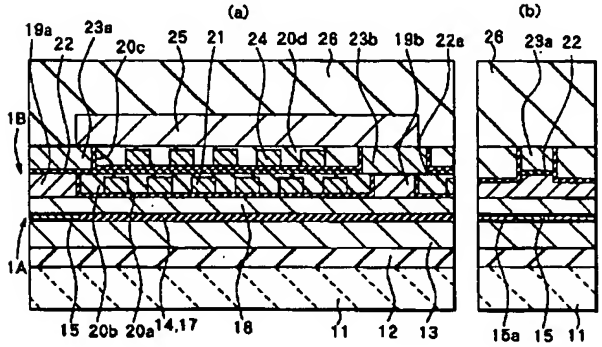

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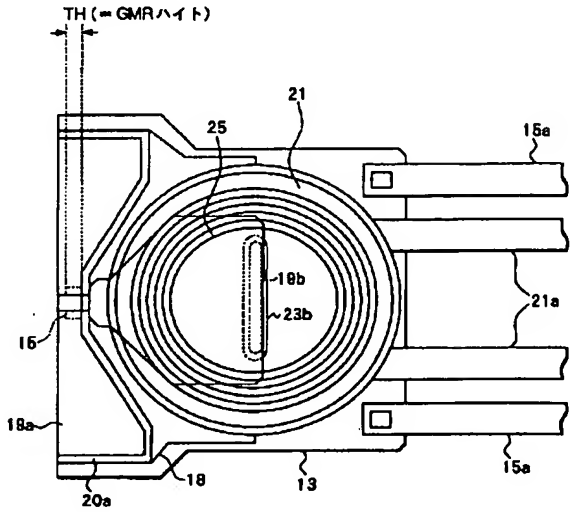

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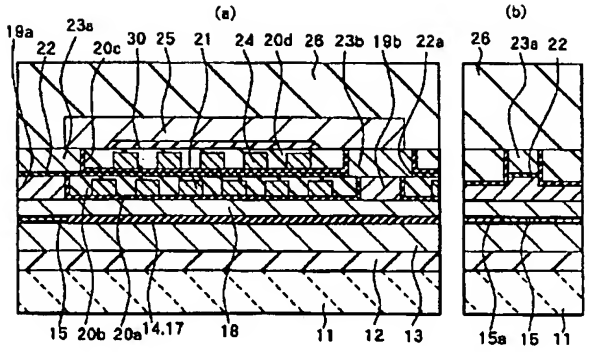

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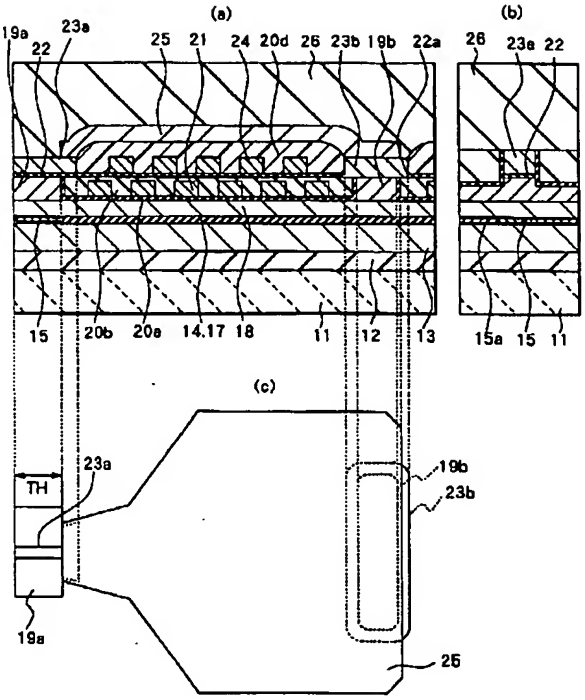

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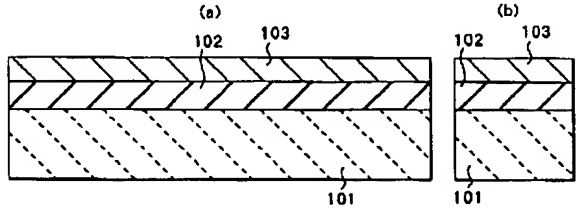

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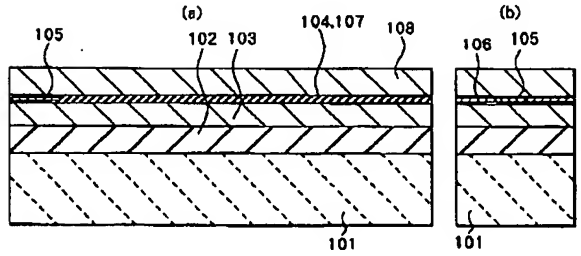

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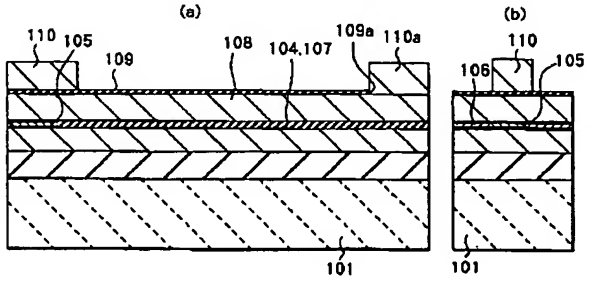
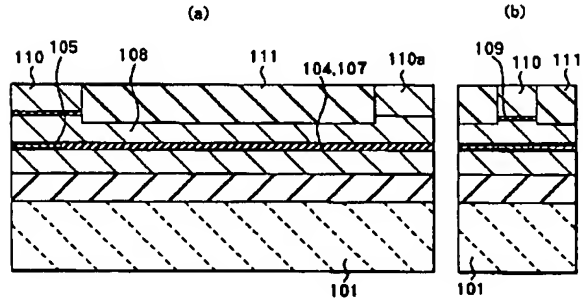
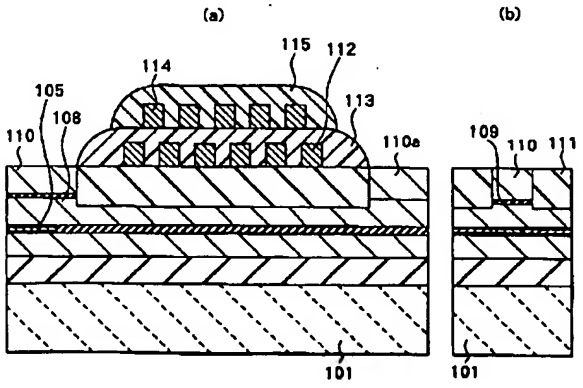


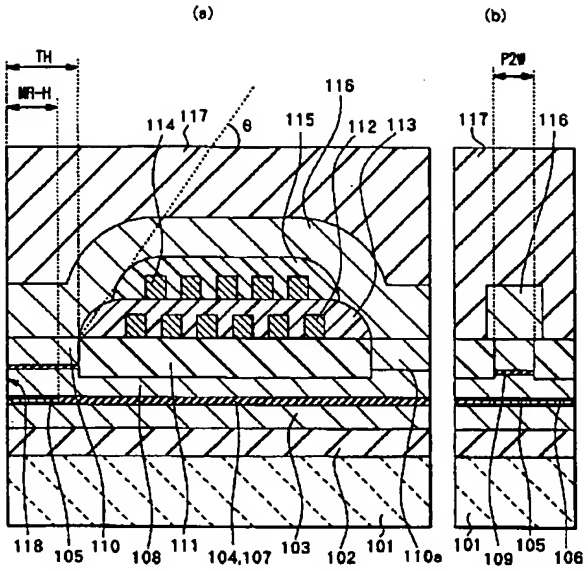
【図14】



【図15】



【図16】


(a)
(b)
TH
MR-H
P2W
116
114
117
θ
115
112
113
117
116
118
105
110
108
111
104,107
103
102
101
110a
101
109
105
106

JP 2000-076620

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] At least two magnetic layers containing the 1st magnetic pole and 2nd magnetic pole which the part of the side which is connected magnetically and counters a record medium counters through a record gap layer, While being the thin film magnetic head which has a thin film coil more than two-layer [for generating magnetic flux / one layer or two-layer], dividing with the 1st magnetic layer and this 1st magnetic layer and being formed While the field of the opposite side of a contact surface with said record gap side is formed in the 1st magnetic pole magnetically combined with the field in part and the inorganic system ingredient of said 1st magnetic layer While countering said 1st magnetic pole through the insulating layer continuously formed in one field of said 1st magnetic layer, and said record gap layer from the opposite side of the side which counters said record medium of said 1st magnetic pole at least While dividing with the 2nd magnetic pole formed towards the back side for a long time than said 1st magnetic pole from the field which counters said record medium, and this 2nd magnetic pole and being formed The thin film magnetic head characterized by having the 2nd magnetic layer magnetically combined with said 2nd magnetic pole in a part of field [at least] of the opposite side of a contact surface with said record gap side of said 2nd magnetic pole.
[Claim 2] The thin film magnetic head according to claim 1 to which die length from the field which counters said record medium of said 1st magnetic pole is characterized by being equal to the throat height of a recording head.
[Claim 3] Said 2nd magnetic pole is the thin film magnetic head according to claim 1 or 2 to which only an equivalent for the thickness of said 2nd magnetic pole is characterized by the ******** rather than said 1st magnetic pole.
[Claim 4] The thin film magnetic head given in claim 1 to which much more thin film coil is characterized by being formed so that a part of the direction of thickness may be located at least in the field in which said insulating layer is formed at least thru/or any 1 term of 3.
[Claim 5] Said insulating layer is the thin film magnetic head according to claim 4 characterized by including the 1st insulating layer continuously formed along one field of said 1st magnetic layer from the opposite side of the side which counters said record medium of said 1st magnetic pole, and the 2nd insulating layer formed between the coils of said thin film coil at least.
[Claim 6] The thin film magnetic head given in claim 1 characterized by being formed so that the opposite side of a contact surface with said 1st magnetic layer of said insulating layer may turn into substantially an opposite side of a contact surface with said record gap layer of said 1st magnetic pole with the same side thru/or any 1 term of 3.
[Claim 7] The thin film magnetic head according to claim 6 characterized by forming more widely than the width of face of said 2nd magnetic pole the width of face along the field which counters said record medium of said 1st magnetic pole.
[Claim 8] Furthermore, it sets near the edge of the opposite side the side which counters said record medium of said 2nd magnetic layer. It has the 1st connection which adjoined said 1st magnetic layer and was formed, and the 2nd connection which adjoined said 2nd magnetic layer and was formed in the

location which counters this 1st connection. And the thin film magnetic head given in claim 1 characterized by the area of the side which counters mutually [said 1st connection and said each of 2nd connection] differing thru/or any 1 term of 7.
[Claim 9] The thin film magnetic head according to claim 8 characterized by the area of said 2nd connection being larger than that of said 1st connection.
[Claim 10] The edge by the side of the field which counters said record medium of said 2nd magnetic layer is the thin film magnetic head given in claim 1 characterized by being formed in the location which retreated from the field which counters said record medium thru/or any 1 term of 9.
[Claim 11] Said 1st insulating layer is the thin film magnetic head given in claim 5 characterized by being further formed along the both-sides side except the end face of the side which counters said record medium of said 1st magnetic pole thru/or any 1 term of 9.
[Claim 12] The thin film magnetic head given in claim 5 characterized by forming all of the directions of thickness of said thin film coil in the field in which said 1st insulating layer is formed thru/or any 1 term of 10.
[Claim 13] The thin film magnetic head according to claim 12 characterized by being formed so that said 2nd insulating layer may serve as substantially a contact surface with said record gap layer of said 1st magnetic pole with the same side.
[Claim 14] The thin film magnetic head according to claim 13 characterized by being formed so that one field of said record gap layer may cover said 2nd insulating layer.
[Claim 15] Furthermore, the thin film magnetic head according to claim 14 characterized by the 3rd insulating layer being missing from the field of another side of said record gap layer, and forming it continuously at least from the opposite side of the side which counters said record medium of said 2nd magnetic pole.
[Claim 16] The thin film magnetic head according to claim 15 characterized by having the thin film coil of at least one layer which was covered with other different insulating layers from said the 1st thru/or 3rd insulating layer, and was further formed between said 3rd insulating layer and said 2nd magnetic layer at them.
[Claim 17] The thin film magnetic head according to claim 16 characterized by being formed so that said the 3rd insulating layer and other insulating layers may serve as substantially an opposite side of a contact surface with said record gap layer of said 2nd magnetic pole with the same side.
[Claim 18] Furthermore, the thin film magnetic head given in claim 1 characterized by having a magneto-resistive effect component for read-out thru/or any 1 term of 17.
[Claim 19] At least two magnetic layers containing the 1st magnetic pole and 2nd magnetic pole which the part of the side which is connected magnetically and counters a record medium counters through a record gap layer, It is the manufacture approach of the thin film magnetic head of having a thin film coil more than two-layer [for generating magnetic flux / one layer or two-layer]. After forming the 1st magnetic layer, said 1st magnetic layer a part on said 1st magnetic layer The process which forms the 1st magnetic pole so that it may be magnetically combined with a field, The process which forms continuously the insulating layer which is missing from one field of said 1st magnetic layer from the opposite side of the side which counters said record medium of said 1st magnetic pole at least, and consists of an inorganic system ingredient, The process which forms said 2nd magnetic pole towards a back side for a long time than said 1st magnetic pole from the field which counters said record medium after forming a record gap layer on said 1st magnetic pole at least, The manufacture approach of the thin film magnetic head characterized by including the process which is magnetically combined with said 2nd magnetic pole, and forms the 2nd magnetic layer.
[Claim 20] Furthermore, while adjoining said 1st magnetic layer and forming the 1st connection in the location near the edge of the side which counters said record medium of said 2nd magnetic layer, and the opposite side at the same time it forms said 1st magnetic pole In the location near the edge of the side which counters said record medium of said 2nd magnetic layer at the same time it forms said 2nd magnetic pole, and the opposite side The manufacture approach of the thin film magnetic head according to claim 19 characterized by adjoining said 2nd magnetic layer and forming the 2nd

connection of a different area from said 1st connection.
[Claim 21] The manufacture approach of the thin film magnetic head according to claim 19 or 20 characterized by including the process which forms much more thin film coil at least so that a part of the direction of thickness may be located at least in the field in which said insulating layer is formed.
[Claim 22] The manufacture approach of the thin film magnetic head according to claim 21 characterized by including the process which forms the 1st insulating layer continuously along one field of said 1st magnetic layer from the opposite side of the side which counters said record medium of said 1st magnetic pole, and the process which forms the 2nd insulating layer between the coils of said thin film coil at least.
[Claim 23] The manufacture approach of the thin film magnetic head according to claim 22 characterized by including the process which carries out flattening so that the opposite side of a contact surface with said 1st magnetic layer of said 2nd insulating layer may turn into substantially an opposite side of a contact surface with said record gap layer of said 1st magnetic pole with the same side.
[Claim 24] The manufacture approach of the thin film magnetic head given in claim 19 characterized by forming more widely than said 2nd magnetic pole the width of face along the field which counters said record medium of said 1st magnetic pole thru/or any 1 term of 23.
[Claim 25] The manufacture approach of the thin film magnetic head given in claim 19 characterized by forming all of the directions of thickness of said thin film coil in the field in which said 1st insulating layer is formed thru/or any 1 term of 24.
[Claim 26] After carrying out flattening of said 2nd insulating layer, a record gap layer is formed on said 2nd insulating layer. After forming said 2nd magnetic pole on said record gap layer, the 3rd insulating layer is formed on said record gap layer at least. Then, the manufacture approach of the thin film magnetic head according to claim 25 which forms the thin film coil of at least one layer on said 3rd insulating layer on said record gap layer, and is characterized by covering said thin film coil continuously by other different insulating layers from said the 1st thru/or 3rd insulating layer.
[Claim 27] said -- others -- after forming an insulating layer with an inorganic system ingredient -- said -- others -- the manufacture approach of the thin film magnetic head according to claim 26 which carries out flattening of the insulating layer so that the front face may form the same field as the front face of said 2nd magnetic pole, and is characterized by forming said 2nd magnetic layer after that on said 2nd magnetic pole and other insulating layers by which flattening was carried out.
[Claim 28] The manufacture approach of the thin film magnetic head according to claim 27 characterized by forming said 2nd magnetic layer on said 2nd magnetic pole and other insulating layers after forming an insulating layer besides the above alternatively with an organic system ingredient.
[Claim 29] Furthermore, the manufacture approach of the thin film magnetic head given in claim 19 characterized by including the process which forms the magneto-resistive effect component for read-out thru/or any 1 term of 28.

[Translation done.]